Myint Swe Khine *Editor*

Knowing, Knowledge and Beliefs

Epistemological Studies across Diverse Cultures

Springer

Knowing, Knowledge and Beliefs
Epistemological Studies across Diverse Cultures

Myint Swe Khine
Editor

Knowing, Knowledge and Beliefs

Epistemological Studies across Diverse Cultures

Springer

Myint Swe Khine
Murdoch University
Perth, Australia

ISBN 978-1-4020-6595-8 e-ISBN 978-1-4020-6596-5

Library of Congress Control Number: 2007936007

Printed on acid-free paper.

9 8 7 6 5 4 3 2 1

springer.com

Preface

What is knowledge? Is knowledge fixed or ever changing? How can we measure individuals' beliefs about the nature of knowledge and knowing? Educational psychologists and researchers have taken keen interest in such questions while attempting to understand the role of beliefs in the learning process. In recent years measurement of epistemological beliefs takes an important role in the study of individuals' beliefs about knowledge. This book brings together prominent educators and researchers from around the world to share their experiences in providing theoretical framework and model building together with contemporary research on the role of epistemological beliefs in learning.

The book is divided into five parts: Part I Introduction; Part II Conceptual and Methodological Issues; Part III Empirical Studies on Cultural-Specific Epistemology; Part IV Perspectives on Domain-Specific Epistemology; and Part V Conclusion.

The introductory chapter in Part I provides a brief overview of personal epistemology from multiple paradigms and review the examples of research conducted across cultures. The chapter also suggests implications of a more culturally informed personal epistemology both for multicultural education and for future research.

The chapters in Part II describe conceptual and methodological issues related to personal epistemology research. The authors presented topics related to assessing teachers' epistemological and ontological worldviews, the evolution of self-authorship, assessing the multidimensionality of students' epistemic beliefs and measurement of epistemological beliefs and learning strategies of elementary school children.

In Part III empirical studies on cultural-specific epistemology are presented. The chapters in this part deal with the studies conducted in Canada, USA, Israel, Cyprus, Spain, Germany, Hong Kong, Taiwan, and Singapore.

Perspectives on domain-specific epistemology are described in Part IV. The concluding chapter in Part V deals with the challenges and future directions for personal epistemology research in diverse culture.

This book would have been an impossible task without generous and enthusiastic support of the international academics in this field. Foremost, I would like to thank Barbara Hofer, Gregory Schraw, Marcia Baxter Magolda, Gale Sinatra, and Marlene Schommer-Aikins for their contributions despite their busy schedules and heavy work commitments. I am indebted to all the contributors who have shared their works in this volume.

I owe gratitude to my associates Dr. Chai Ching Sing and Dr. Benjamin Wong who have provided suggestions and helped me in editorial work. I would also like to acknowledge Harmen van Paradijs of Springer for taking up this challenging task.

I hope that this book will be a useful resource in future research on personal epistemology.

Murdoch University
Perth, Western Australia

Myint Swe Khine

Contents

About the Contributors

Andrea Anschuetz studied sociology, education and psychology at the University of Oldenburg (Germany). She works as a research assistant in the project: The influence of immediate feedback on subsequent learning in children. In her doctoral dissertation she examines epistemological beliefs of elementary school children.

Charoula Angeli has BS and MS in Computer Science and Ph.D. in Instructional Systems Technology from Indiana University, USA. She is presently an Assistant Professor in Instructional Technology, Department of Education, University of Cyprus.

Lisa D. Bendixen is an Associate Professor in the Department of Educational Psychology at the University of Nevada, Las Vegas. She received her Ph.D. in Educational Psychology from the University of Nebraska-Lincoln in 1998. Her research focuses on personal epistemology and how it impacts teaching and learning.

Donna Berthelsen is a senior lecturer in educational and developmental psychology in the School of Early Childhood at the Queensland University of Technology. She has professional qualifications in teaching and psychology. Donna is engaged in ongoing research projects with her colleague, Joanne Brownlee, that explores the epistemological beliefs of students and practising teachers in early childhood education programs and the relationships between the nature of those beliefs and their teaching practice. Donna is also engaged in other national educational and developmental research projects which are funded by the Australian government focussed on evaluation of early education intervention programs as well as longitudinal research on family and social influences on children's development and well-being at home and school.

Angela Boldrin is a Ph.D. student at the University of Padua, Italy. She graduated in psychology summa cum laude. Her research interest deals with personal epistemology in learning processes, especially in relation to Internet-based instruction.

Ivar Bråten is a professor of Educational Psychology in the Department of Educational Research at the University of Oslo, Norway. His research focuses on beliefs, learning, and comprehension, with a special emphasis on the roles that epistemological and motivational beliefs play in text-based learning and comprehension. He is currently directing the project Learning in a Knowledge Society: Constructing Meaning from Multiple Information Sources, funded by the Norwegian Research Council. Dr. Bråten has published his research in such prestigious journals as the Journal of Educational Psychology, Cognition and Instruction, Reading Research Quarterly, and Contemporary Educational Psychology, and he is a regular presenter at international conferences such as the meetings of the American Educational Research Association and the European Association for Research on Learning and Instruction.

Joanne Brownlee is a senior lecturer in the School of Early Childhood at the Queensland University of Technology. Her current research investigates early childhood professionals' personal epistemology and the impact of such beliefs on early childhood practice. This line of research has also been extended recently to include child care centre directors and how leadership styles are impacted by epistemological beliefs. This research is important because there are substantial implications for such beliefs on caregivers' practice, and subsequent quality, in long day care.

Rainer Bromme is a professor for Educational Psychology within the Department of Psychology at the Westfälische Wilhelms-Universität, Münster, Germany. He received his PhD in Psychology in 1979. He is in Münster since 1995, from 1992 until 1995 he had a position as full professor at the Department of Psychology in Frankfurt/Main and before as Senior Researcher at the Institute for Research in Mathematics Education (IDM) at the University of Bielefeld (a national research institute on Mathematics Education). His current research interests include cognition and teaching/learning processes, especially related to the development of knowledge and understanding in Science and Mathematics, learning with New Media, communication and cooperation between experts and laypersons, and development of professional expertise.

Michelle M. Buehl is an Assistant Professor in the College of Education and Human Development at George Mason University. Her research interests include issues related to student and teacher beliefs in relation to learning, motivation, and academic development. In previous studies, she has explored the domain-specificity of epistemic beliefs as well as the relations between beliefs and motivation for students of varying ages. More recently, she has begun to examine practicing and preservice teachers' beliefs about pedagogical knowledge.

Dr. Francisco Cano studied Educational Psychology at the Sorbonne in Paris and obtained a PhD in Psychology from Granada University (Spain) in 1990. He is currently Assistant Professor of Educational Psychology at Granada University and is a member of the European Association for Research in Learning and Instruction (EARLI). His research focuses on students' learning experience (learning approaches, beliefs and achievement goals) and his articles have been published in many prestigious European and American academic journals.

Dr. María Cardelle-Elawar received a Ph.D in Educational Psychology and MS in Statistics from Stanford University, and MA in Educational Psychology from the University of Southern California. She is a member of the American

Educational Research Association (AERA) and of the European Association for Research on Learning and Instruction (EARLI). Her research informs her teaching, and her teaching inspires her research, and both are disseminated through her professional service at the international, national, and community levels. Her research agenda on metacognitive instruction, motivational variables affecting teacher identity, and beliefs of teachers and students about teaching and learning is a continuation of a stream of research that began with her dissertation at Stanford. She has published on Journal of Educational Psychology, and Teaching and Teacher Education: An International Journal, The European Journal of Psychology in Education, the Learning and Instruction Journal, and Action in Teacher Education. She was recipient of a national Burlington Northern Teaching Award for excellence in Teaching at the graduate and undergraduate level. Recently, she was a keynote speaker on emotional intelligence and positive psychology at the international level.

Ching Sing Chai holds a Bachelor of Arts degree in Chinese Literature from National Taiwan University. He joined the teaching profession for seven years, after obtaining his Postgraduate Diploma for Education. He received his Master of Art (Instructional Design and Technology) from Nanyang Technological University, Singapore. He completed his doctoral study at the University of Leicester. He is currently an assistant professor at the National Institute of Education, Nanyang Technological University. His research interest is in the field of teachers' beliefs and computer-supported collaborative learning.

Kwok-wai Chan, PhD, FCOLLP, is a senior lecturer in the Department of Educational Psychology, Counselling and Learning Needs of the Hong Kong Institute of Education. Dr. Chan has rich experiences in teacher education, secondary school teaching, administration and research. He has published extensively articles in international referred journals and book chapter writings. His research interests include epistemological beliefs, conceptions of learning and teaching, learning approaches and strategies, motivation and goal orientation, and teacher professional development.

Florian C. Haerle obtained his PhD (2005) with summa cum laude in Curriculum and Instruction from the Carl von Ossietzky University in Germany. He holds degrees in special education, educational science, and gifted and talented education. His scholarly interests and research expertise focuses on personal epistemology, inclusive education, and technology-supported qualitative research. On the national and international level, he has presented and published research on children's personal epistemology and epistemic climate in elementary classrooms. Currently, Dr. Haerle is a visiting scholar at the University of Nevada, Las Vegas, USA.

Barbara K. Hofer is an Associate Professor at Middlebury College in Middlebury, Vermont. She received an Ed.M. in Human Development from the Harvard Graduate School of Education and a Ph.D. in Education and Psychology from the University of Michigan, with a certificate in Culture and Cognition. She is the recipient, with Paul Pintrich, of the Research Review Award from the American Educational Research Association for a review of the literature on epistemological theories, and is also co-editor of Personal Epistemology: The Psychology of Beliefs about Knowledge and Knowing. Her current research interests include epistemological development in adolescence (funded by the National Science Foundation), epistemic metacognition in online learning, and the relation between epistemic beliefs and strategy use, learning, and motivation. She also conducts research on culture, cognition, and learning; self-regulation; and autonomy development in adolescence and emerging adulthood.

Dorothe Kienhues is a research fellow at the University of Münster, Germany, Department of Educational Psychology. She received a diploma in Psychology (2005) with a thesis about changing epistemological beliefs. She holds a scholarship of the German Research Foundation DFG ('Deutsche Forschungsgemeinschaft') and is a member of the Virtual Ph.D. Program (VGK) 'Knowledge Acquisition and Knowledge Exchange with New Media'. Her current research interests include epistemological beliefs, especially the mechanism of epistemological change, critical thinking, conceptual change, and possibilities and limits of using new media for teaching and learning.

Myint Swe Khine is an Associate Professor in the Division of Arts at Murdoch University, Australia. He received his Master degrees from the University of Southern California, USA and University of Surrey, UK and Doctor of Education from Curtin University of Technology, Australia. He has co-edited and published books which include *Studies in Educational Learning Environments: An International Perspective* (2002) (World Scientific), *Classroom Management: Facilitating Teaching and Learning* (2005) (Prentice-Hall), *Empowering Learning: Becoming a Strategic Learner* (2005) (McGraw-Hill), *Teaching with Technology: Strategies for Engaging Learners* (2006) (Prentice-Hall) and *Engaged Learning with Emerging Technologies* (2006)(Springer).

Oliver Lüdtke is a research scientist at the Centre for Educational Research at the Max Planck Institute for Human Development, Berlin, Germany. His main research interests include role of epistemological beliefs in educational settings, the modelling of effects of classroom factors on individual development, and the role of personality development in school and university contexts.

Marcia Baxter Magolda is Distinguished Professor of Educational Leadership at Miami University of Ohio (USA). Her scholarship addresses the evolution of learning and development in college and young adult life, the role of gender in development, and pedagogy to promote self-authorship. Her books include Learning Partnerships: Theory and Models of Practice to Educate for Self-Authorship (2004), Making Their Own Way: Narratives for Transforming Higher Education to Promote Self-Development (2001), Creating Contexts for Learning and Self-Authorship: Constructive-Developmental Pedagogy (1999), and Knowing and Reasoning in College (1992). She serves as the Executive Editor of About Campus: Enriching the Student Learning Experience.

Rose M. Marra, Ph.D., is an Associate Professor in the School of Information Science and Learning Technologies at the University of Missouri. Her research interests include gender equity issues, the epistemological development of college students, and promoting meaningful learning in web-based environments. She was previously faculty in Penn State's College of Engineering; she continues her work in engineering education in federally funded grants studying women in engineering and K-12 engineering education initiatives.

Lucia Mason is a Professor of Educational Psychology at the University of Padua, Italy. Her main research interest has been conceptual change. She has carried out studies on analogical reasoning, argumentation in group discussions, and writing-to-learn as a tool for knowledge revision. On these themes she has published essays and articles nationally and internationally. She has also edited a special issue of "Learning and Instruction" and a special issue of "Educational Psychologist", and co-edited two volumes published by Kluwer Academic Publishers. Her current research focuses on the role of personal epistemology in learning processes, especially conceptual change. On this topic she has published articles in national and international journals, essays in international volumes, and a book in Italian. In 1993 she was Fulbright research scholar at the University of Georgia, USA. In 2003 she was the recipient of the European Association for Research on Learning and Instruction (EARLI) Outstanding Publication Award. She is currently an associate editor of the new journal "Educational Research Review", and a member of the editorial boards of "Contemporary Educational Psychology", "Instructional Science", "Education Psychologist", "Journal of Experiment Education", and Metacognition and Learning".

Barbara Moschner studied psychology and education at the University of Trier (Germany) and at Boston University (USA). She received her diploma and her doctoral degree from the University of Trier. Since 2001 she is professor for Empirical Research in Learning and Instruction at the School of Education Carl von Ossietzky University of Oldenburg in Germany. Her main interests are in individual prerequisites of learning e.g. epistemological beliefs, self-concept, self-regulated learning, learning motivation and interest. Current research grant: The influence of immediate feedback on subsequent learning in children.

Krista R. Muis, (Ph.D., Simon Fraser University) is an Assistant Professor in Educational Psychology at the McGill University, Canada. Her research interests include how students' epistemic beliefs influence various facets of cognition and behavior. She is also interested in exploring what cognitive operations are involved in learning mathematics. Moreover, both lines of research are brought together under models of self-regulated learning. She has published eight articles and book chapters and has presented over 25 papers at national and international meetings. In 2005, Dr. Muis won the Dunlop Award, for Outstanding Doctoral Dissertation in Canada (Awarded by the Canadian Society for the Study of Education), and the Dean of Graduate Studies Convocation Medal for Academic Excellence, from Simon Fraser University.

Dr. Lori Olafson is an associate professor in the Department of Educational Psychology at the University of Nevada, Las Vegas. She received her Ph.D. from the University of Calgary in Alberta, Canada. At the University of Nevada, Las Vegas she teaches qualitative research methods. Her current research interests include teachers' beliefs and practices, moral reasoning, and students' perceptions of assessment. Her first book, a study of adolescent girls' disengagement from school, was recently published.

Betsy Palmer, Ph.D., is an Associate Professor of Adult and Higher Education/Educational Research and Statistics at Montana State University. Her research interests include the epistemological development of college students, enhancement of university-level teaching methods, the scholarship of teaching and innovations in engineering education. In her own teaching she has utilized problem-based learning, feminist pedagogies, distance-delivered learning, service learning, and other active-learning techniques. She is currently pursuing cross-cultural research on the tertiary education system in Nepal.

Marlene Schommer-Aikins is a professor of educational psychology at Wichita State University, USA. She earned a Masters in Educational Psychology from the University of Wisconsin-Milwaukee and a Ph.D. in Educational Psychology from University of Illinois at Champaign-Urbana. Her research investigates beliefs about the nature of knowledge and learning, or epistemological beliefs. Since her first publication in this area (Schommer, 1990) she has theorized the multidimensional nature of personal epistemology; developed the first questionnaire to assess these beliefs; conducted studies linking epistemological beliefs to comprehension and metacomprehension. She has also examined the development, domain specificity, and complex effects of epistemological beliefs.

Gregory J. Schraw (Ph.D., M.S. Statistics) is a professor of educational psychology and Barrick Distinguished Scholar at the University of Nevada, Las Vegas. Dr. Schraw's research interests include personal epistemologies, text relevance, metacognition, and situational interest. He is co-director of the Center for Evaluation and Assessment at UNLV, where he teaches classes in learning, instruction, statistics, and research methodology. He is a recipient of the American Psychological Association's Richard Snow Early Career Achievement Award and is former program chair of APA Division 15. In addition, he works extensively in the area of large scale assessment, focusing on test alignment and school improvement issues related to No Child Left Behind.

Gale M. Sinatra, (Ph.D., University of Massachusetts) is a Professor of Educational Psychology at the University of Nevada, Las Vegas, and Editor of the APA, Division 15 Journal, Educational Psychologist. Her research interests include human learning, knowledge acquisition, knowledge and belief change, literacy acquisition, assessment and text comprehension. She has published over 30 articles and book chapters and dozens of paper presentations at national and international meetings in these areas. Dr. Sinatra's recently book, co-edited with Dr. Paul Pintrich, Intentional Conceptual Change, examines how students can be catalysts of their own knowledge restructuring.

Elmar Stahl is a full professor at the University of Education, in Freiburg, Germany. He received a diploma in Psychology with a thesis about binocular rivalry (visual perception) in 1995. In 2001 he received his Ph.D. with a thesis about knowledge acquisition and learning processes by writing hypertexts. In 2006 he received his habilitation (= a kind of second PhD Thesis, common in Germany to qualify for a tenure position as a full professor). His current research xvi About the Contributors Khine_Fm.indd xvii 10/17/2007 1:10:18 PM interests include research and teaching on video-based learning, epistemological beliefs, learning by writing hypertexts and help seeking within interactive learning environments.

Iris Tabak is a Lecturer (Assistant Professor) in the Department of Education at Ben Gurion University of the Negev, Israel. She received her Ph.D. in Learning Sciences at Northwestern University and holds a B.S.E in Computer Engineering from The University of Michigan. Her interests include inquiry-based learning in science; the design of computer-based learning environments; the relationship between epistemological, conceptual and strategic knowledge; subject-matter learning and identity formation; classroom discourse; as well as design-based and mixed research methods.

Ulrich Trautwein is a research scientist at the Centre for Educational Research at the Max Planck Institute for Human Development, Berlin, Germany. His main research interests include the role of epistemological beliefs in educational settings, the effects of different learning environments on academic achievement, self-concept, personality development and the role of self-related cognitions in students' homework behaviour.

Professor Chin-Chung Tsai holds a Bachelor of Science degree in physics from National Taiwan Normal University, Taiwan. He received a Master of Education degree from Harvard University and a Master of Science degree from Teachers College, Columbia University. He completed his doctoral study also at Teachers College, Columbia University, 1996. From 1996–2006, he joined the faculty at Institute of Education, he is currently a Professor at Institute of National Chiao Tung University, Hsinchu, Taiwan. He is currently a Professor at Graduate school of Technological and Vocational Education, National Taiwan University of Science and Technology, Taiwan (e-mail cctsai@mail.nctu.edu.tw). His research interests deal largely with epistemological beliefs, science education and Internet-based instruction. In recent five years, he has published more than forty more than forty papers in English-based international journals.

Nicos Valanides is an Associate Professor in Science Education, Department of Education, University of Cyprus. He holds BA in Physics from the University of Thessaloniki, Greece, Teaching Diploma and MA in Education (Science Teaching) from the American University of Beirut (AUB), Lebanon, BA in Law (Public Law and Political Sciences), from the University of Thessaloniki Greece, MSc (Instructional Supervision) and Ph.D. (Curriculum and Instruction) from the State University of New York (SUNY) at Albany.

Uta Wagener has a diploma in psychology and a teacher's exam from the University of Oldenburg (Germany). She has worked as a research assistant in different areas and as a psychologist in a kindergarten for children with special needs. She is currently working on her dissertation on self-regulated learning of young school children. Her main interests are self-regulated learning, learning strategies, metacognition, qualitative research and video-analysis.

Michael Weinstock is a Lecturer (Assistant Professor) in the Department of Education at Ben-Gurion University of the Negev. He received his Ph.D. in developmental psychology from Teachers College, Columbia University. His research interests include folk epistemology, epistemology in the disciplines, and various aspects of argument such as argument skills, the use of evidence and explanation in argument, and the identification of informal reasoning fallacies.

Stephan Wernke has teacher's exam from the University of Oldenburg (Germany). He is currently working as a research assistant in a project dealing with the development of blended learning units for students in teacher education programs. In his dissertation project he is developing a training program for self-regulated learning in elementary school children.

Dr. Benjamin Wong is Assistant Professor in the Policy and Leadership Studies Academic Group. He was formerly a lecturer at the National University of Singapore where he held a joint appointment in the Department of Political Science and the University Scholars Programme. He is currently involved in the Leaders in Education Programme and serving as the coordinator of the pre-service programme in his department. His teaching and research interests include the history of moral and political philosophy, virtue and leadership, critical thinking, as well as knowledge and inquiry.

Part I
Introduction

Chapter 1
Personal Epistemology and Culture

Barbara K. Hofer

Abstract The role that personal epistemology plays in intellectual development, learning, and education has been investigated for several decades in the USA (see Hofer & Pintrich, 1997, 2002) and has recently been pursued in other cultural environments. Research suggests that epistemological understanding has important implications for learning: for example, beliefs about the nature of knowledge may influence strategy use, comprehension, cognitive processing, and conceptual change learning. However, the primary constructs regarding students' conceptions of knowledge and knowing were all developed with US college students, and the initial research on which most models are based was conducted with white males at an elite institution in the 1950s and 1960s (Perry, 1970). Furthermore, measurement of epistemic beliefs has typically been formulated and validated in the USA and then applied in other cultures by translating existing instruments and presuming similar factor structures. In recent years, however, research on epistemic beliefs and development has been expanding in its comprehensiveness, particularly in regard to research in multiple cultures, providing potential challenges and possible expansion of existing models. In this introductory chapter, I will provide a brief overview of personal epistemology from multiple paradigms (Hofer, 2004b), review examples of research conducted across cultures, and suggest implications of a more culturally informed personal epistemology both for multicultural education and for future research.

1.1 Introduction

The role that personal epistemology plays in intellectual development, learning, and education has been investigated for several decades in the USA (see Hofer & Pintrich, 1997, 2002; Hofer, 2001 for overviews) and has more recently been actively pursued by researchers in a range of other cultural environments. However,

---

Middlebury College, Vermont, USA

M. S. Khine (ed.), *Knowing, Knowledge and Beliefs: Epistemological Studies across Diverse Cultures.*

the primary constructs regarding students' conceptions of knowledge and knowing were all developed with US college students (King & Kitchener, 1994; Schommer, 1990), and the initial research on which most models of personal epistemology are based was conducted with white males at an elite US institution (Harvard) in the 1950s and 1960s (Perry, 1970). Origins such as these suggest why generalizing the scheme even within the USA has been problematic and why a critical reexamination is necessary in conducting research on personal epistemology in cultures beyond the one where the theory was derived. This is an exciting time for cultural research in this field and this book fills an important need. There is a vast potential for expanding the construct as the research develops and evolves with broader cultural influences.

In addition, it is not only the model that has western origins, but research on the cognitive outcomes and educational implications of personal epistemology was established first in the USA and the findings from those studies are often the basis for studies elsewhere. Studies conducted primarily in the USA, for example, suggest that beliefs about the nature of knowledge and knowing influence strategy use (Schommer et al., 1992), cognitive processing (Kardash & Howell, 2000), motivation (Buehl & Alexander, 2005), and conceptual change learning (Qian, 2000), among other constructs. Recent work in European contexts suggests similarities (Braten & Stromso, 2006; Mason, 2001, 2003b) and there is arguably more research currently being conducted on these issues by European scholars than in the USA. We know little, however, about whether similar relations among constructs would be expected in other cultures, and have reason to suspect the patterns might not be universally applicable, based on differences in fundamental assumptions and beliefs about what it means to know and to learn (Li, 2003; Tweed & Lehman, 2002).

Furthermore, measurements of personal epistemology have largely been formulated and validated in the USA and then applied to other cultures by translating existing instruments. This type of practice seems to operate from the underlying assumption that the dimensions, stages, and directionality of suggested progressions are applicable across cultures, if not universal – a large assumption that may need questioning. A growing number of studies suggest that the factor structure of epistemic beliefs, as measured by instruments that originated in the USA, may not be similar in other contexts (Chan & Elliott, 2002; Youn, 2000). What is even less understood is whether there are dimensions of epistemology expressed in other cultures but not represented in the schemes developed in the USA, one of many fruitful topics for future research.

In recent years research on epistemic beliefs and development has been expanding in its comprehensiveness, particularly in regard to research in multiple cultures, providing potential challenges and possible expansion of existing models. In this chapter I will provide a brief overview of personal epistemology from multiple paradigms, review some examples of research conducted across and within diverse cultures, and suggest implications of a more culturally informed personal epistemology both for multicultural education and for future research.

1.2 Personal Epistemology: Individual Conceptions of Knowledge and Knowing

How individuals view knowledge and knowing has been studied under the general heading of "personal epistemology" (Hofer & Pintrich, 2002), with several particular paradigmatic approaches (Hofer, 2004b). What all these approaches have in common is a psychological approach to the philosophical field of epistemology, focusing on what individuals believe about what counts as knowledge and where it resides, how individuals come to know, and how knowledge is constructed and evaluated. Developmental psychologists have typically been most interested in the patterned sequence of epistemic understanding over time, and educational psychologists more concerned with how epistemic beliefs are a part of and an influence on the cognitive processes of thinking and reasoning. Science and math educators have eagerly entered the beliefs arena as well, furthering our understanding of domain-specific beliefs and also contributing other paradigmatic models. Although there are multiple frameworks for investigating personal epistemology, the two that are currently most commonly employed in research across cultures are epistemological development and epistemic beliefs.[1]

1.2.1 Epistemological Development

Developmental approaches to personal epistemology vary somewhat, but nearly all seem to share some common assumptions about a general trajectory of development (see Hofer & Pintrich, 1997, for more detailed comparisons of the models). Most early schemes were constructed on the basis of research with college populations and ignored early epistemological development, but more recent research has helped sketch an outline for the origins of epistemic thinking, Researchers have suggested that very young children begin at a state of *naïve realism* (Chandler et al., 2002) or *egocentric subjectivity* (Burr & Hofer, 2002), a period in which their own perception of knowing is the only view accessible to them, a mode of thinking that is transformed in the attainment of theory of mind (Wellman et al., 2001), typically between 3 and 5 years of age. This cognitive transition permits awareness that others may have different beliefs, desires, and intentions, thus ushering in the potential for acknowledging others' knowledge states, and some early sense of epistemic objectivity. The highly recognizable phase of *dualism* or *absolutism* follows, and the hallmark is a belief in objectivity. Individuals view knowledge as certain, unambiguous, and dichotomous, believing

[1] I am using the term "epistemic" to modify beliefs, as these are beliefs about knowledge and knowing (the epistemic), not beliefs about epistemology (R. F. Kitchener, 2002). Conversely, I am using "epistemological" to modify development, as this refers to the development of an individual's personal epistemology.

that there is a right and wrong, and that knowledge is black and white. Knowing occurs through learning from those who know these truths and can transmit them.

The dualist worldview is modified when individuals begin to encounter and accept shades of gray and to recognize the imperfections and fallibility of authorities. Thus *multiplists* are subjectivists, but in a different manner than toddlers. Lacking the egocentrism of early childhood, they acknowledge a multiplicity of viewpoints but lack the means to differentiate among them, supposedly accepting all positions as equally valid. Developmentally, individuals transcend this when they begin to see that some positions are better than others, some authorities more reliable, and that there is means to justify, substantiate, and support what one knows and how one knows it. This permits a reconciliation of objectivity and subjectivity, in a stage identified as *evaluativism* (Kuhn & Weinstock, 2002), in which the knower also begins to reconcile one's own experiences of knowing with externally derived knowledge (Belenky et al., 1986).

Although this is only a loose sketch of an overall developmental scheme, and the number of stages or levels varies between 3 and 9 steps across models, it captures the general trend. What is often missing from such accounts, unlike many other developmental schemes (moral development, cognitive development, the development of perspective taking, etc.) is some sense of expected ages, which is suggested only during the earliest years of the scheme. Here the research has gaps and contradictions, with questions raised about whether development is cyclical or recursive (Chandler et al., 2002), for example. As yet, there is too little research in childhood and adolescence to ascertain what happens during these rather large formative periods, and what research we do have suggests that stages once expected to appear initially in college may actually happen earlier. Clearly more work is needed, particularly during adolescence, to refine this scheme of development, which will also make it of greater use to educators, as well as make it more useful in other cultural settings or in cross-cultural work. Most troubling about the research on such schemes from an educational perspective is the finding that a relatively small number of individuals in the USA samples studied appear to reach the highest level, miring them in worldviews that are either dichotomous or overly relativistic (King & Kitchener, 1994; Kuhn, 1991).

We know very little about how these schemes replicate in other cultures, whether the developmental trajectory is consistent, or whether the higher levels of the schemes in particular are grounded in Western education (Moore, 2002) and are unlikely to appear in the same sequence elsewhere. In one cross-cultural study of Perry's scheme (Zhang, 1999), Chinese students showed different cognitive developmental patterns than the US students in the study, with students in Beijing exhibiting a reverse pattern from US students: they became more dualistic in the course of their college education. As Zhang notes (in recalling Perry, 1970), cognitive development is a result of a person–environment interaction, and at the particular time Beijing students were queried in this study (1994), the educational system may have been likely to foster a press toward absolutism, with predetermined majors and few opportunities for individuals to make their own decisions. Research such as this suggests that we need to be sensitive to multiple aspects of cultural contexts as well as to the changing nature of cultural influence.

Weinstock and Tabak (this volume) have used the three-stage model of epistemological development to compare Israeli adolescents from two distinct backgrounds, Bedouin and Jewish. Finding that Bedouins had higher percentages of absolutists than did Jews in all domains, they interpreted this as indicative of both cultural and school influences. In another study by Weinstock and colleagues (Weinstock et al., 2006), epistemological level as assessed through a Hebrew translation of a measure of epistemological development (Kuhn et al., 2000) indicated an association with level and grade (7, 9, and 11). Results also indicated a relation between epistemological level and ability to identify one type of logical fallacy, independent of cognitive ability or grade level.

Similar research on epistemological development and the skills of argumentation has been conducted by Mason and Scirica with middle school students in Italy. Students read texts about the controversial topics of genetically modified food and global warming and also completed the 15-item instrument developed by Kuhn et al. (2000) as an assessment of epistemological understanding, which taps five domains (judgments of personal taste, aesthetics, values, truth about the social world and truth about the physical world). Students are scored as absolutists, multiplists, or evaluativists on the basis of whether they assert that only one view could be right, if both could be right, and if the latter, if one view could be better than another. Among other findings, the authors found that advanced epistemological understanding (i.e., evaluatism) was a significant predictor of the three components of argumentation skills: arguments, counterarguments, and rebuttals providing justification.

Other models of epistemological development have been pursued in cultural contexts apart from where they originated as well. A Finnish study of reflective judgment, based on the work of King and Kitchener (1994), investigated implicit epistemologies during adulthood (Pirtilla-Backman & Kajanne, 2001). In this interview-based longitudinal study, formal education was the primary predictor of development, and the authors also suggest the significance of cultural change during the time period in which the study was conducted and the influence this is likely to have on implicit epistemologies. Current work is underway in expanding the model of self-authorship (Baxter Magolda, 2001) across cultures; a central component of that model is epistemological development.

A central concern in the study of epistemological development has been measurement issues. Assessment has been most reliable and valid with interviews, no doubt leading to the complexity of conducting these studies in other countries. Numerous attempts have been made to advance paper and pencil measures, with some difficulty (Wood et al., 2002) and some moderate successes. Weinstock, Kuhn, and their colleagues' continued development of their written instrumentation (Kuhn et al., 2000), as described earlier, has made it possible to examine relations between epistemological level and other constructs, and more work on this front in likely to advance the field.

One concern is that simplified written measures may risk trivializing the complexity and richness of the various levels; for example, if multiplism is measured by the acknowledgement that more than one view is acceptable, then many young children have already achieved a level of development that Perry (1970) found most common among college sophomores. Recent studies using similar domains and prompts ("Can more than one view be right?") provide evidence that there is acceptance of multiple viewpoints in some domains during the preschool and early elementary years (Wainryb et al., 2004; Wildenger et al., in press). The field needs finer-grained measures and schemes than ones that would classify personal epistemology at vastly different points in life as categorically similar, and a three-stage model may not capture the full span of development adequately, although it is a highly useful heuristic framework. The need for further advancement of written measures of epistemological development continues as a pressing concern and the current limitations of such measures may help explain why less work has been done from this paradigmatic perspective in other cultures than from the beliefs framework.

Further research across cultures on epistemological development could help advance an understanding of whether the trajectory described earlier is as normative outside western schooling as within, and this might be done by repeating versions of the early phenomenological work of Perry (1970) and others, or through additional replications of reflective judgment studies. It would serve the field well to have studies that are more inclusive of other cultural worldviews at the theoretical and conceptual foundation as well as more comparative studies of cultures in regard to epistemological development.

1.2.2 Epistemic Beliefs

The most commonly utilized paradigm for exploring personal epistemology in diverse cultures has been that of epistemic (Schraw et al., 2002) or epistemological (Schommer, 1990) beliefs. From this perspective, individuals' ideas about knowledge and knowing are multidimensional and the dimensions may not necessarily develop in a unified way. In developmental models, by contrast, although there is recognition of some of the same components of epistemic thinking as in the beliefs models, the general sense is that these develop in a coordinated fashion.

The original model for epistemological beliefs was proposed by Schommer (1990), who has suggested that there are five dimensions, four of which she has identified empirically: certain knowledge, simple knowledge, quick learning, and innate ability. The fifth one, omniscient authority, is clearly important theoretically and is a significant component in some developmental schemes (Belenky et al., 1986). Not all models also include these same dimensions. As described elsewhere (Hofer & Pintrich, 1997), the first two dimensions are also common to developmental trajectories, and the latter two seem to have less relation to a definition of epistemology, with its concern for knowledge and knowing, and are drawn from other psychological constructs (e.g., Dweck's research on beliefs about ability). The four dimensions of personal epistemology that are suggested by a review of the extant literature are two dimensions related to the nature of knowledge – certainty of knowledge, and simplicity of knowledge, and two related to the nature of knowing – source of knowledge, and justification for knowing. These have had some empirical support as well (Hofer, 2000, 2007; Karabenick & Moosa, 2005). A review of studies in several Asian cultures supported the general twofold structure of the nature of knowledge and nature of knowing, with the number of factors within each of these areas as dependent on instrumentation and cultural context (Chan & Elliott, 2004).

Measurement of epistemic beliefs is typically conducted through questionnaires, with Likert-scale responses to items, most commonly with the Epistemological Beliefs Questionnaire, as designed by Schommer (1990) or the Epistemological Beliefs Inventory (Schraw et al., 2002). A number of the items on the Schommer questionnaire were drawn from Perry's original instrument, designed in part to assess authoritarianism and used by Perry to select subjects for his interviews nearly 50 years ago. Although these items have been criticized as being vague and overly general (e.g., "I don't like movies that don't have endings," "Self-help books are not much help") (Buehl et al., 2002; Hofer & Pintrich, 1997), they have persisted in use, which may attribute to a number of the problems that have arisen in utilizing this scheme to make predictions about outcomes of epistemic beliefs. Other researchers have designed similar questionnaires, some domain general (Schraw et al., 2002; Wood & Kardash, 2002) and some domain specific (Buehl & Alexander, 2005; Hofer, 2000). (For discussion of domain specificity, see Muis et al., 2006; Hofer, 2006).

It is within the paradigm of epistemic beliefs that the research on personal epistemology has most proliferated across cultures and it is not possible to do justice to all the work that has been conducted, nor is it within the scope of this chapter. Examples must suffice. Some of the work aims at testing the models and the factors within new cultural settings, other research focuses on assessing outcomes, and other studies are comparative in nature, examining two or more cultures. A considerable body of research has been conducted in Europe (e.g., Braten et al., 2005; Bromme, 2003; Cano, 2005; Clarebout et al., 2001; De Corte et al., 2002; Mason, 2003b; Mason & Boscolo, 2004; Mason & Scrivani, 2004), with collegial interaction on the topic facilitated through a formal network of researchers. Research is now growing dramatically in Asia, with significant work appearing from Taiwan (Tsai, 2000, 2004, 2005; Tsai, 1998, 1999a), Korea (Youn, 2000), Hong Kong (Chan & Elliott, 2002), and Singapore (Chai et al., 2006), for example, and it is rapidly spreading elsewhere, with work now underway in Egypt, Saudi Arabia, Brazil, Argentina, and many other regions of the world.

Researchers working within this tradition have coped with issues of transporting the ideology of an instrument devised in another culture and translating it (in the majority of cases where the native language is not English), hoping that the original factors may replicate. This does not always occur, however – nor is it always the case within the USA, particularly when a general epistemic beliefs instrument is utilized as the basis for an item-level factor analysis (Hofer, 2000; Qian & Alvermann, 1995). Chan and Elliott (2002), for example, in a study of teacher education students in Hong Kong, found that dimensions differed from the factors Schommer has identified in ways that were interpretable by culture. For example, the importance of effort in learning was associated with the process of learning, as might be expected, based on the Confucian heritage of the culture. The authors conclude that "care needs to be exercised" in applying the questionnaire in other cultural contexts, a noteworthy caution. A similar study of preservice teachers in Singapore (Chai et al., 2006), using an adaptation of Schommer's instrument similar to the one used by Chan and Elliott (2002), revealed a comparable structural model with similar means and higher reliabilities coefficients. The emphasis on effort and process in this study provides additional support for the cultural basis of beliefs and the distinct nature of epistemic beliefs in Confucian cultures.

In cases such as the one above, the comparison with results in the USA is implied, as the results within a second culture are examined in light of what has been identified in much of the published literature on epistemic beliefs research in the USA. A good number of studies, however, have made more explicit and direct comparisons between cultures, employing the same instrument in diverse environments. Youn, for example, replicated a study of US students (Jehng et al., 1993) among both Korean and US students. Results of administering a 71-item survey (Jehng et al.'s items and 13 new ones) suggested that the five-factor model failed to emerge in either sample, and two basic factors were identified in each culture, called "Knowledge" (22 items) and "Learning" (12 items). The US factors were conceptually consistent with Jehng et al.'s model, with beliefs about learning and beliefs about knowledge as distinct factors, each containing predicted aspects of the five dimensions. The Korean model, by contrast, linked authority with the other learning processes (innate ability and "quick process"), which Youn interprets as evidence of a more personal model of learning than in Schommer's original samples, congruent with Youn's description of the teacher–student relationship in Korea (Youn, 2000).

A study comparing 11th and 12th graders in the USA and China (Qian & Pan, 2002) utilizing a domain general instrument (Qian & Alvermann, 1995) with three scales (certain-simple knowledge, quick learning, and innate ability) showed low internal consistency among the Chinese for certain-simple knowledge (.27). This has arguably been the core dimension of epistemology across a range of US studies, and typically the most robust, thus this low reliability is of some concern. Chinese students were more likely to view knowledge as simple/certain and ability innate, and US students more likely to view learning as quick or not at all.

Other cross-cultural studies have used a discipline-based approach to investigating epistemic beliefs. In one such study, college students from Oman and the USA were queried in regard to beliefs about science (Karabenick & Moosa, 2005), using a revised version of a discipline-specific instrument (Hofer, 2000). The four factors of the model (certainty, simplicity, source, and justification) were at least partially evident in the factor structure and interpretable across the two cultures. Examination of gender and country effects showed that males were more likely than females, regardless of country, to believe that knowledge was simple, and Omani men were more likely than Omani woman to accept scientific authority without question. A particularly interesting finding in this study is that regardless of country, the more experience students had with science the more students believed that scientific knowledge was unchanging. Overall, the study indicates the importance of also looking at other variables, such as gender, that may predict differences by culture, and the value of examining the underlying cultural values that are expressed through epistemic beliefs, which are explicated by the authors in this article.

In a parallel study conducted in Japan and the USA with a modified version of a discipline-based instrument (Hofer, 2000), I utilized psychology as the discipline of interest and assessed college students enrolled in introductory psychology courses. Results showed support for the four-factor structure across both samples (Hofer, 2007), as well as cultural differences. US college students were "more sophisticated" in their beliefs about all four factors – certainty, simplicity, source, and justification – than were Japanese students, raising questions about socialization of secondary schooling in the two countries and cultural values of authority in particular, as well as the appropriateness of the evaluative labeling of the current continuum of beliefs and its relevance to other cultures.

Not surprisingly, such sharp contrasts are most likely when the cultures under comparison differ dramatically, particularly in views of authority, and less so when the cultures are similar and when no translation is required. (For a more extensive review of beliefs research in the USA, Hong Kong, and Taiwan, see Chan & Elliott, 2004). A study of college students in the USA and Britain showed little differences in epistemological beliefs about research on psychological and biological development, other than more overall skepticism about the research in both fields in the USA (Estes et al., 2003).

As journal reviewers, editors, and researchers alike know quite well, numerous other cross-cultural studies have been conducted that failed to replicate the findings of earlier studies and so remain unpublished, as failures to replicate are seldom deemed worthy of publication. As a result, we are often unaware of the complexities of conducting research across cultures on personal epistemology or the actual stability of our schemes, and know little about the infrequency with which replication might actually occur or how the factor structure might look when it does not resemble the western-based model. Ideally, researchers might benefit from opportunities to see more work in progress and to find means to collaborate in cultural analyses of complex results that may not be easily interpretable. Recent advances in online networks and the potential this provides for sharing of unpublished studies may be promising in this regard. Another concern that often plagues replication studies of epistemic beliefs in diverse cultures is that when cultural differences are identified, sometimes too many variables have been changed to know which variables are responsible for the differences in findings (e.g., students are enrolled in different types of educational institutions or majors). This makes it difficult to ascertain whether differences are primarily attributable to culture or to other confounding variables.

One of the major contributions across cultures has been the growing research that links epistemic beliefs to other constructs, a body of work that continues to grow in the USA and is particularly strong among European researchers and a cluster of researchers in Taiwan. For example, Mason and her colleagues in Italy have a broad and substantial program of research in this regard, examining the relation between beliefs and theory change (Mason, 2000), intentional conceptual change (Mason, 2003b), problem solving in math (Mason, 2003a), etc. Braten and Stromso in Norway, have been similarly engaged in identifying connections between epistemic beliefs and such constructs as achievement goals (Braten et al., 2005), text-processing strategies (Braten & Stromso, 2006), and learning with the Internet (Braten et al., 2005). The latter issue has been a large topic of study among the prolific work of Tsai's research team in Taiwan (Peng et al., 2006; Tsai, 2004; Wu & Tsai, 2005) as well as investigated in the USA (Hofer, 2004a). Tsai and colleagues have also examined a wide range of issues regarding learning in science (Tsai, 2000, 2005; Tsai, 1999a, 1999b), laying groundwork for work that has extensive application across cultures in the science education community. Researchers have also investigated changes in beliefs during secondary school in Spain and their relation to achievement (Cano, 2005) and, in a multi-country, multiply translated study in Europe, the effects of instructional innovations on beliefs (Elen & Clarebout, 2001).

These examples are illustrative of the large body of work that has been developing in this area and indicate the need for a more comprehensive and detailed analysis of this research. Moreover, as is the case with all the studies cited in this chapter, these are examples of work appearing in English-language journals and books, and omit more domain-specific research (e.g., math beliefs) that often appears in disciplinary journals. Researchers in personal epistemology lack any sort of clearinghouse that might alert us to the full panoply of the investigations taking place, and this research appears to be growing exponentially.

What is critically important in linking epistemic beliefs and understanding to other constructs is to question assumptions about whether the relations are likely to be similar across cultures. In the comparative study of 11th- and12th-grade students in China and the USA mentioned earlier (Qian & Pan, 2002), results showed that although students with higher academic success have been shown to have more "sophisticated beliefs" in the USA (Schommer & Dunnell, 1994), this was not evident among Chinese students. The authors note that beliefs about certainty and simplicity of knowledge are likely to be influenced by school cultures that discourage assertiveness and challenging of authority. This does not appear to lead to lower performance in such a community. Similarly in the study that I conducted with Japanese and US students (Hofer, 2007), although Japanese students showed substantially more reverence for authority and belief in the certainty and simplicity of knowledge, this does not indicate that they perform less well in the cultural context in which they are schooled. Between-culture comparisons of achievement show robust findings that Japanese students outperform US students in assessments of math and science in particular (Stevenson et al., 1993). We need more studies that include achievement variables and involve both within- and between-country analyses in order to better understand the predictive nature of epistemic beliefs across cultures.

Conceptions of knowledge and knowing are critical to understand not only of students, but also of teachers, as indicated by the research on teachers' worldviews (Schraw & Olafson, 2002) and the findings on changes in preservice teachers' beliefs (Gill et al., 2004). This area of investigation has had substantial development in Australia under the leadership of Brownlee (Brownlee, 2003; Brownlee & Berthelsen, 2006; Brownlee et al., 2001; Brownlee, 2001), with work spanning a wide range of issues with relevance to teacher education and teacher beliefs.

Researchers employing the epistemic beliefs paradigm in diverse cultures can make the greatest contributions to the field, I think, through a more critical examination of the construct as it is currently manifested and measured and by advancing a shared understanding of cultural nuance about this construct. We are in need of new theoretical contributions that expand the conceptual model rather than simply testing it in new contexts, and more empirical validation studies of new measures across cultures. We also need broader critiques of both the construct (Bromme, 2003) and the dimensionality of the models (Rozendaal et al., 2001).

1.3 Other Models of Personal Epistemology

One of the growing areas of research on personal epistemology is the expansion beyond familiar paradigms and approaches. In the USA, Hammer and Elby have argued for a view of "epistemological resources," for example, a more fine-grained, context-based approach to understanding students' conceptions of knowledge and knowing and how they bring them to bear on specific classroom tasks (Hammer & Elby, 2002). Although this model has had less empirical testing, it has been a useful heuristic for interpreting epistemic understanding. For example, Chai et al. (2006), in a review of research on preservice teachers' epistemological beliefs note that most research indicates that preservice teachers view teaching as a simple act of transmitting knowledge; the authors use Hammer and Elby's model to explain that these teachers, when thinking about teaching, are drawing on epistemological resources that treat knowledge as told rather than knowledge as invented. From a resources perspective, this does not mean that teachers are at a low level of development or have unsophisticated beliefs, but that the idea of teaching evokes particular epistemological resources. Presumably, the challenge for teacher educators would be to help elicit other more productive resources.

Other researchers have expanded on epistemic authority as a core issue. A study of Israeli students and teachers indicates that teachers see themselves as more of an epistemic authority than students do and erroneously believe that students share their perception (Raviv et al., 2003). Another new model of personal epistemology with relevance for the professional workplace (rather than educational settings) has been investigated in the Netherlands (Tillema & Orland-Barak, 2006). These researchers examined views of knowledge and knowing categorized as reflective, situated, and constructivist, and looked at beliefs about the process of knowing within each. These are only brief examples of some of the newer models and explorations under investigation and the field is likely to benefit significantly from this expanded thinking about individuals' views of knowledge and knowing.

Synthetic views have also been proposed, including an integrative model with considerable possibilities that merit testing (Bendixen & Rule, 2004). Pintrich and I posited the idea of *epistemic theories*, noting that the idea of "beliefs" might convey something less organized and coherent, and that individual conceptions of knowledge and knowing, although multidimensional, are likely to be interconnected (Hofer & Pintrich, 1997), as developmental models suggest. More recently, I have attempted to build on the work of others (Kitchener, 1983; Kuhn, 2000) in returning to the idea of epistemic metacognition (Hofer, 2004a). I continue to think that the concept is a complex and multifaceted one and that no single paradigm is likely to enable researchers to capture this. As posited elsewhere, I view personal epistemology as an *identifiable set of dimensions of beliefs about knowledge and knowing, organized as theories, progressing in reasonably predictable directions, activated in context, operating both cognitively and metacognitively* (Hofer, 2005). This does not mean that personal epistemology can necessarily be studied in such complexity in any one study, but that it may be helpful to consider this synthetic view of the construct and how what each of us advances in our research contributes to the whole. It also suggest limitations, however, in some of our forms of measurement, particularly the use of Likert-scale items, as a number on a continuum cannot capture the complexity of the developmental reorganization of beliefs (Hofer, 2005). I look forward to learning how researchers from a broad array of cultures might expand the thinking about the construct further and the potential of new forms of measurement.

1.4 The Future of Research on Personal Epistemology Within and Across Cultures

Psychology is now in a similar position in regard to culture that it once was in regard to gender, not so very long ago, and the parallels may be instructive for those of us conducting research on personal epistemology. For many decades psychological research routinely involved research with male subjects (mostly college students, and mostly white), and theory building grew from this research alone. Women were often omitted from this critical stage of research; when the resulting constructs and instruments were applied to them, they were being compared against a standard that did not include their perceptions in the formation of the theory. As Gilligan (1982) and others noted, this sometimes led to women inappropriately being judged deficient. For example, when assessed with Kohlberg's moral judgment interviews, constructed from a male sample, women scored lower than men, appearing less rational in their judgments about morality. Gilligan, through a series of her own interviews, began to recognize an ethic of care that had been omitted from the Kohlberg scheme, which focused more on justice, and argued for a morality that included both constructs (Gilligan, 1982). In the area of personal epistemology, Belenky et al. were able to provide a contrastive view to Perry's scheme by interviewing women, and only women (from diverse backgrounds and ages, another notable difference), with similar questions, developing a scheme that includes both separate and connected knowing (Clinchy, 2002), and a synthesis of the two, among other contributions (Belenky et al., 1986). Baxter Magolda, also interested in gender and epistemology, interviewed both males and females in a longitudinal study during the college years (Baxter Magolda, 1992) and beyond (Baxter Magolda, 2001, 2004) and identified gender-related patterns of epistemic reasoning.

Much as research on personal epistemology may have been overly gender specific in its origins, the conceptual foundation may also be culturally biased, given its basis in research with US college students. We do not yet know the degree to which this restricts our understanding and distorts our findings (even within the USA, much less beyond), and we need more research of the type described earlier regarding gender, as applicable to culture. As illustrated by Belenky et al.'s (1986) work and their interviews with women, this could involve interviews in other cultures that might lead to the identification of stages and/or dimensions not readily evident in western society, for example. We also need to examine the directional nature of beliefs (what counts as sophistication) and the hierarchies of the developmental levels, just as Gilligan (1982) did for moral development. Additional studies that would parallel Baxter Magolda's approach to studying both genders would be those that include two or more cultures and permit comparisons as well as more inclusive theory building.

Cultural research in psychology has been described as containing two stages of scientific inquiry (Heine & Norenzayan, 2006). The first stage involves seeking cultural differences and establishing the boundaries of a phenomenon. The second stage of research involves the pursuit of underlying mechanisms of those cultural differences. Researchers investigating personal epistemology are beginning to close in on Stage 1 and are beginning to address the issues of Stage 2. More such work is most definitely needed, particularly in regard to addressing differences in high-contrast cultures with differing assumptions about the very meaning of learning, for example, with either Socratic or Confucian influences (Tweed & Lehman, 2002), each of which suggest the potential for differing beliefs about knowledge and knowing.

1.5 Formative Questions for Culture and Personal Epistemology Research

Research on personal epistemology is expanding around the globe and the chapters in this volume are testimony to the array of work that is underway in diverse cultures. Researchers involved in these investigations have much to gain from working together and from thinking critically about the work that lies ahead. I hope the following questions may be useful to consider as this work evolves.

(1) Do we have a construct that is representative of personal epistemology as conceived across cultures? Are there dimensions of epistemic beliefs that might be missing from a US derived model but that would be important to delineate in a more culturally comprehensive and inclusive model? When we work primarily from a replication model we risk privileging a cultural worldview and we shortchange our investigations. The dimensionality of epistemology needs a fresh examination from multiple cultural lenses. We also need to refine our methods in ways that enable us to identify what aspects of personal epistemology are conceivably universal and which may be culturally specific. The search for psychological universals has been identified as a foundational postulate of the discipline, but the methods for pursuing this have been lacking, and are only beginning to be defined (Norenzayan & Heine, 2005).
(2) What might we learn from expanding our work beyond college students in industrialized nations and taking a more anthropological approach to indigenous beliefs and the understanding of "folk psychology," as the construct is viewed by philosophers (R. Kitchener, 2002)? It would be beneficial to continue to extend this work not only to both younger and older populations (as have Kuhn, 1991, and King & Kitchener, 1994), but to subcultures and ethnic groups within countries, as well as to less industrialized nations. In a chapter on "Knowing: How do People Come to Know What They Know?" in his book *Folk Psychologies*, Thomas describes how cultures may distinguish between *knowing* and the *capacity to know*. Furthermore, sources of knowledge across cultures are hardly limited to those researchers typically consider when studying students in traditional classrooms. These can include human nature (or innate knowledge), personal experience, models, instruction (both apprenticeships and schooling), dreams, visions, possession, and fantasies (Thomas, 2001). As the author notes, cultures also differ in the degree to which these sources of information are considered to provide "true knowledge." In some cultures what is regarded as true might be what authorities convey, and in others it might be what is directly experienced. And in others, of course, it might be what is empirically verified. Opening our understanding to these genuinely diverse models might lead us toward a far more comprehensive and accepting model of psychological epistemology.
(3) Is the directionality of our models common across cultures? In other words, as noted earlier, is what is regarded as "sophisticated beliefs" in one culture similarly favored and fostered in another, and are those that are consider "less sophisticated" always so, regardless of context and culture? In many contexts, for example, accepting authority is likely to be appropriate. Our current models are neither context-sensitive nor culturally nuanced, and the labeling appears pejorative. Greater cultural explorations may help us move away from the hegemony of western ideas of "sophistication" and towards a view of epistemic understanding that is more contextual and culturally situated.
(4) Do we have measures that are adequate for cross-cultural studies? Are the measures culturally appropriate and can terms survive translation? Is translation and back-translation sufficient to assume shared meaning? Some items from

western instruments (e.g., “Nothing is certain but death and taxes”) clearly do not survive translation well, as is evident from a recent report of translation issues in Saudi Arabia (Schreiber & Al-Ghalib, 2007). Do the essential terms even translate well? While preparing this chapter I was corresponding with a colleague in Egypt who said he had read the materials on epistemology but had difficult with one issue: “What is the difference between knowledge and knowing? They are the same word in Arabic.” This indicates just how difficult this undertaking can be.

(5) Are we overly focused on individual knowing and ignoring socially distributed aspects of knowledge (Bromme, 2003)? A vast body of research on the individualism and collectivism of cultures (Triandis, 2001) and the independent and interdependent construals of self (Markus & Kitayama, 1991) suggests that we need to question this most basic assumption. Our views of “personal” epistemology may overlook a more situated, shared view of cognition and knowing.

(6) What is implied when factor structures do not replicate? Is it essential that they do, in order to make valid comparisons? Youn’s (2000) work shows how it may be possible to explain differing factor structures and use this as a basis for meaningful investigation of cross-cultural differences. This type of work is common in some of the other social sciences, such as political science, where cross-cultural work has a longer history. For example, the items that suggest “faith in government” might not be identical in multiple cultures but within each country they are suggestive of a common underlying idea. Yet in psychology, we have been more resistant to this practice, and may need to rethink this, provided we are confident about the nature of the construct and can reasonably defend the variations we identify.

(7) What is the applicability and predictive nature of personal epistemology in diverse cultures? Can we draw on an integration of broader psychological and educational literature to help us make richer predictions? Research on the linkages between epistemic beliefs and such constructs as learning strategies and achievement may not neatly replicate in other cultures, where the models of learning and authority differ (Hofer, 2007; Qian & Pan, 2002). We need to know much more about the educational systems, values, and beliefs of those cultures in order to predict and interpret our findings, rather than assuming that relations among these variables are universal.

(8) How might cultural psychology (Rogoff, 2003) direct us toward better interpretation of the findings in multiple cultures? Can we better illuminate the cultural basis of epistemology through an investigation of socialization and acculturation practices? Some of the richest work that can develop in this field is to move beyond cross-cultural comparisons toward deeper within-country explanations of how individuals come to believe what they do about knowledge and knowing, the “Stage 2” model of cultural psychology described earlier (Heine & Norenzayan, 2006). A sample of this type of work is a recent study of beliefs of Israeli students enrolled in either general or religious schools with an examination of how various practices shape these beliefs (Gottlieb, 2007).

(9) What are the educational implications of a more culturally informed personal epistemology and how can this help shape teaching practices in multicultural classrooms, for example? Increased migration, globalization, and multiple examples of intercultural conflict on this planet call for attention within our schools to awareness of differing epistemic assumptions, views of authority, and understandings of what it means to know. Teaching with such sensitivity and toward the goal of an increased cultural competency among students is a critical need. Teachers also need to be aware of the tension students may experience when epistemic beliefs of home and school are in conflict.

(10) Finally, how can we work together and collaborate to build and enrich our models, test our hypotheses, and expand our networks of cultural understanding? Fundamentally, I would suggest that what is needed is more cross-cultural collaboration so that we can work on the design of measurements that are culturally sensitive and expand our theoretical and conceptual basis, as well as carry out studies together and interpret findings from diverse perspectives.

There is important work to be done and we need increased dialogue and opportunities to share work in progress. This book is a fine step along that path.

References

Baxter Magolda, M. B. (1992). *Knowing and reasoning in college: Gender-related patterns in students' intellectual development*. San Francisco, CA: Jossey Bass.

Baxter Magolda, M. B. (2001). *Making their own way: Narratives for transforming higher education to promote self-development*. Sterling, VA: Stylus.

Baxter Magolda, M. B. (2004). Evolution of a constructivist conceptualization of epistemological reflection. *Educational Psychologist*, 39, 31–42.

Belenky, M. F., Clinchy, B. M., Goldberger, N. R., & Tarule, J. M. (1986). *Women's ways of knowing: The development of self, voice and mind*. New York: Basic Books.

Bendixen, L. D., & Rule, D. C. (2004). An integrative approach to personal epistemology: A guiding model. *Educational Psychologist*, 39, 69–80.

Braten, I., & Stromso, H. I. (2006). Constructing meaning from multiple information sources as a function of personal epistemology: The role of text-processing strategies. *Information Design Journal*, 14(1), 56–67.

Braten, I., Stromso, H. I., & Samuelstuen, M. S. (2005). The relationship between internet-specific epistemological beliefs and learning within internet technologies. *Journal of Educational Computing Research*, 33(2), 141–171.

Bromme, R. (2003). Thinking and knowing about knowledge: A plea for and critical remarks on psychological research programs on epistemological beliefs. In M. H. G. Hoffman, J. Lenhard, & F. Seeger (Eds.), *Activity and sign: Grounding mathematics education* (pp. 1–11). Dordrecht, The Netherlands: Kluwer.

Brownlee, J. (2003). Changes in primary school teachers' beliefs about knowing: A longitudinal study. *Asia-Pacific Journal of Teacher Education*, 31, 87–98.

Brownlee, J. M. (2001). Knowing and learning in teacher education: A theoretical framework of core and peripheral epistemological beliefs. *Asia Pacific Journal of Teacher Education and Development*, 4, 167–190.

Brownlee, J., & Berthelsen, D. (2006). Personal epistemology and relational pedagogy in early childhood teacher education programs. *Early Years*, 26, 17–29.

Brownlee, J., Purdie, N., & Boulton, L. G. (2001). Changing epistemological beliefs in pre-service teacher education students. *Teaching in Higher Education*, 6, 247–268.

Buehl, M. M., & Alexander, P. A. (2005). Motivation and performance differences in students' domain-specific epistemological belief profiles. *American Educational Research Journal*, 42, 697–726.

Buehl, M. M., Alexander, P. A., & Murphy, P. K. (2002). Beliefs about schooled knowledge: Domain specific or domain general? *Contemporary Educational Psychology*, 27, 415–449.

Burr, J. E., & Hofer, B. K. (2002). Personal epistemology and theory of mind: Deciphering young children's beliefs about knowledge and knowing. *New Ideas in Psychology*, 20, 199–224.

Cano, F. (2005). Epistemological beliefs and approaches to learning: Their change through secondary school and their influence on academic performance. *British Journal of Educational Psychology*, 75, 203–221.

Chai, C. S., Khine, M. S., & Teo, T. (2006). Epistemological beliefs on teaching and learning: A survey among pre-service teachers in Singapore. *Educational Media International*, 43, 285–298.

Chan, K., & Elliott, R. G. (2002). Exploratory study of Hong Kong teacher education students' epistemological beliefs: Cultural perspectives and implications on beliefs research. *Contemporary Educational Psychology*, 27, 392–414.

Chan, K., & Elliott, R. G. (2004). Epistemological beliefs across cultures: Critique and analysis of beliefs structure studies. *Educational Psychology*, 24, 123–142.

Chandler, M. J., Hallett, D., & Sokol, B. W. (2002). Competing claims about competing knowledge claims. In B. K. Hofer & P. R. Pintrich (Eds.), *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 145–168). Mahwah, NJ: Erlbaum.

Clarebout, G., Elen, J., Luyten, L., & Bamps, H. (2001). Assessing epistemological beliefs: Schommer's questionnaire revisited. *Educational Research and Evaluation*, *7*(1), 53–77.

Clinchy, B. M. (2002). Revisiting women's ways of knowing. *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 63–87).

De Corte, E., Eynde, O. T., & Verschaffel, L. (2002). "Knowing what to believe": The relevance of students' mathematical beliefs for mathematics education. In B. K. Hofer & P. R. Pintrich (Eds.), *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 297–320). Mahwah, NJ: Erlbaum.

Elen, J., & Clarebout, G. (2001). An invasion in the classroom: Influence of an ill-structured innovation on instructional and epistemological beliefs. *Learning Environments Research*, *4*, 87–105.

Estes, D., Chandler, M., Horvath, K. J., & Backus, D. W. (2003). American and British college students' epistemological beliefs about research on psychological and biological development. *Applied Developmental Psychology*, 23, 625–642.

Gill, M. G., Ashton, P. T., & Algina, J. (2004). Changing preservice teachers' epistemological beliefs about teaching and learning in mathematics: An intervention study. *Contemporary Educational Psychology*, 29, 164–185.

Gilligan, C. (1982). *In a different voice: Psychological theory and women's development*. Cambridge, MA: Harvard University Press.

Gottlieb, E. (2007). Learning how to believe: Epistemic development in cultural context. *Journal of the Learning Sciences*, 16(1), 5–35.

Hammer, D., & Elby, A. (2002). On the form of a personal epistemology. In B. K. Hofer & P. R. Pintrich (Eds.), *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 169–190). Mahwah, NJ: Erlbaum.

Heine, S. J., & Norenzayan, A. (2006). Toward a psychological science for a cultural species. *Perspectives on Psychological Science*, 1, 251–269.

Hofer, B. K. (2000). Dimensionality and disciplinary differences in personal epistemology. *Contemporary Educational Psychology*, 25, 378–405.

Hofer, B. K. (2001). Personal epistemology research: Implications for learning and instruction. *Educational Psychology Review,* 13(4), 353–382.

Hofer, B. K. (2004a). Epistemological understanding as a metacognitive process: Thinking aloud during online searching. *Educational Psychologist*, 39(1), 43–55.

Hofer, B. K. (2004b). Introduction: Paradigmatic approaches to personal epistemology. *Educational Psychologist*, 39, 1–3.
Hofer, B. K. (2005). The legacy and the challenge: Paul Pintrich's contributions to personal epistemology research. *Educational Psychologist*, 40, 95–105.
Hofer, B. K. (2006). Beliefs about knowledge and knowing: Domain specificity and generality. *Educational Psychology Review,* 18, 67–76.
Hofer, B. K. (April, 2007). Learning strategies and epistemic beliefs: Cultural influences in Japan and the US. *Paper presented at the American Educational Research Association*. Chicago.
Hofer, B. K., & Pintrich, P. R. (1997). The development of epistemological theories: Beliefs about knowledge and knowing and their relation to learning. *Review of Educational Research*, 67, 88–140.
Hofer, B. K., & Pintrich, P. R. (Eds.). (2002). *Personal epistemology: The psychology of beliefs about knowledge and knowing*. Mahwah, NJ: Erlbaum.
Jehng, J. -C. J., Johnson, S. D., & Anderson, R. C. (1993). Schooling and students' epistemological beliefs about learning. *Contemporary Educational Psychology*, 18, 23–25.
Karabenick, S. A., & Moosa, S. (2005). Culture and personal epistemology: US and middle eastern students' beliefs about scientific knowledge and knowing. *Social Psychology of Education*, 8, 375–393.
Kardash, C. M., & Howell, K. L. (2000). Effects of epistemological beliefs and topic-specific beliefs on undergraduates' cognitive and strategic processing of dual-positional text. *Journal of Educational Psychology*, 92, 524–535.
King, P. M., & Kitchener, K. S. (1994). *Developing reflective judgment: Understanding and promoting intellectual growth and critical thinking in adolescents and adults*. San Francisco, CA: Jossey-Bass.
Kitchener, K. S. (1983). Cognition, metacognition, and epistemic cognition. *Human Development*, 26, 222–232.
Kitchener, R. (2002). Folk epistemology: An Introduction. *New Ideas in Psychology*, 20, 89–105.
Kuhn, D. (1991). *The skills of argument*. Cambridge: Cambridge University Press.
Kuhn, D. (2000). Metacognitive development. *Current Directions in Psychological Science*, 9, 178–181.
Kuhn, D., & Weinstock, M. (2002). What is epistemological thinking and why does it matter? In B. K. Hofer & P. R. Pintrich (Eds.), *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 121–144). Mahwah, NJ: Erlbaum.
Kuhn, D., Cheney, R., & Weinstock, M. (2000). The development of epistemological understanding. *Cognitive Development*, 15, 309–328.
Li, J. (2003). US and Chinese cultural beliefs about learning. *Journal of Educational Psychology*, 95, 258–267.
Markus, H. R., & Kitayama, S. (1991). Culture and the self: Implications for cognition, emotion, and motivation. *Psychological Review*, 98, 224–253.
Mason, L. (2000). Role of anomalous data and epistemological beliefs in middle school students' theory change about controversial topics. *European Journal of Psychology of Education*, XV, 329–346.
Mason, L. (2001). Responses to anomalous data on controversial topics and theory change. *Learning and Instruction*, 11, 453–483.
Mason, L. (2003a). High school students' beliefs about maths, mathematical problem solving, and their achievement in maths: A cross-sectional study. *Educational Psychology*, 23(1), 73–85.
Mason, L. (2003b). Personal epistemologies and intentional conceptual change. In G. M. Sinatra & P. R. Pintrich (Eds.), *Intentional conceptual change* (pp. 199–236). Mahwah, NJ: Erlbaum.
Mason, L., & Boscolo, P. (2004). Role of epistemological understanding and interest in interpreting a controversy and in topic-specific belief change. *Contemporary Educational Psychology*, 29, 103–128.
Mason, L., & Scrivani, L. (2004). Enhancing students' mathematical beliefs: An intervention study. *Learning and Instruction*, 14, 153–176.

Moore, W. S. (2002). Understanding learning in a postmodern world: Reconsidering the Perry scheme of intellectual and ethical development. In B. K. Hofer & P. R. Pintrich (Eds.), *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 17–36). Mahwah, NJ: Erlbaum.

Muis, K. R., Bendiyen, L. D., and Haerle, F. C. (2006). Domain gearality and domain specificity in personal epistemological research: Philosophical and empirical reflection in the development of a theoretical model. *Educational Psychology Review,* 18, 3–54.

Norenzayan, A., & Heine, S. J. (2005). Psychological universals: What are they and how can we know? *Psychological Bulletin*, 131, 763–784.

Peng, H., Tsai, C. -C., & Wu, Y. -T. (2006). University students' self-efficacy and their attitudes toward the Internet: The role of students' perceptions of the Internet. *Educational Studies*, 32(1), 73–86.

Perry, W. G. (1970). *Forms of intellectual and ethical development in the college years: A scheme*. New York: Holt (Rinehart & Winston).

Pirtilla-Backman, A. -M., & Kajanne, A. (2001). The development of implicit epistemologies during early and middle adulthood. *Journal of Adult Development*, 8, 81–97.

Qian, G. (2000). Relationship between epistemological beliefs and conceptual change learning. *Reading and Writing Quarterly*, 16, 59–74.

Qian, G., & Alvermann, D. (1995). Role of epistemological beliefs and learned helplessness in secondary school students' learning science concepts from text. *Journal of Educational Psychology*, 87(2), 282–292.

Qian, G., & Pan, J. (2002). A comparison of epistemological beliefs and learning from science text between American and Chinese high school students. In B. K. Hofer & P. R. Pintrich (Eds.), *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 365–385). Mahwah, NJ: Erlbaum.

Raviv, A., Bar-tal, D., Raviv, A., Biran, B., & Sela, Z. (2003). Teachers' epistemic authority: Perceptions of students and teachers. *Social Psychology of Education*, 6, 17–42.

Rogoff, B. (2003). *The cultural nature of human development*. Oxford: Oxford University Press.

Rozendaal, J. S., de Brabander, C. J., & Minnaert, A. (August, 2001). Boundaries and dimensionality of epistemological beliefs. *Paper presented at the 9th Conference of the European Association for Research on Learning and Instruction*. Fribourg, Switzerland.

Schommer, M. (1990). Effects of beliefs about the nature of knowledge on comprehension. *Journal of Educational Psychology*, 82, 498–504.

Schommer, M., & Dunnell, P. A. (1994). A comparison of epistemological beliefs between gifted and non-gifted high school students. Roeper Press, 16(3), 207–210.

Schommer, M., Crouse, A., & Rhodes, N. (1992). Epistemological beliefs and mathematical text comprehension: Believing it is simple does not make it so. *Journal of Educational Psychology*, 82, 435–443.

Schraw, G., & Olafson, L. (2002). Teachers' epistemological world views and educational practices. *Issues in education: Contributions from Educational Psychology*, 8, 99–148.

Schraw, G., Bendixen, L. D., & Dunkle, M. E. (2002). Development and evaluation of the Epistemic Belief Inventory (EBI). In B. K. Hofer & P. R. Pintrich (Eds.), *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 261–275). Mahwah, NJ: Erlbaum.

Schreiber, J., & Al-Ghalib, S. (April, 2007). Beliefs and cognitive processing: An examination of American and Saudi Arabian undergraduates. *Paper presented at the American Educational Research Association*, Chicago.

Stevenson, H. W., Chen, C., & Lee, S. -Y. (1993). Mathematics achievement of Chinese, Japanese, and American children: Ten years later. *Science*, 259 (January 1), 53–58.

Thomas, R. M. (2001). *Folk psychologies across cultures*. Thousand Oaks, CA: Sage.

Tillema, H., & Orland-Barak, L. (2006). Constructing knowledge in professional conversations: The role of beliefs on knowledge and knowing. *Learning and Instruction*, 16, 592–608.

Triandis, H. (2001). Individualism and collectivism: Past, present, and future. In D. Matsumoto (Ed.), *Handbook of cultural psychology* (pp. 35–50). Oxford: Oxford University Press.

Tsai, C. -C. (2000). Relationships between student scientific epistemological beliefs and perceptions of constructivist learning environments. *Educational Research*, 42, 193–205.

Tsai, C. -C. (2004). Beyond cognitive and metacognitive tools: The use of the Internet as an "epistemological" tool for instruction. *British Journal of Educational Technology*, 35, 525–536.

Tsai, C. -C. (2005). Developing a multi-dimensional instrument for assessing students' epistemological views toward science. *International Journal of Science Education*, 27, 1621–1638.

Tsai, C. C. (1998). An analysis of scientific epistemological beliefs and learning orientations of Taiwanese eighth graders. *Science Education*, 82(4), 473–489.

Tsai, C. C. (1999a). Content analysis of Taiwanese 14 year olds' information processing operations shown in cognitive structures following physics instruction. *Research in Science and Technological Education*, 17(2), 125–138.

Tsai, C. C. (1999b). "Laboratory exercises help me memorize the scientific truths": A study of eighth graders' scientific epistemological views and learning in laboratory activities. *Science Education*, 83(6), 654–674.

Tweed, R. G., & Lehman, D. R. (2002). Learning considered within a cultural context: Confucian and Socratic approaches. *American Psychologist*, 57, 89–99.

Wainryb, C., Shaw, L. A., Langley, M., Cottam, K., & Lewis, R. (2004). Children's thinking about diversity of belief and in the early school years: Judgments of relativism, tolerance, and disagreeing persons. *Child Development*, 75, 687–703.

Weinstock, M., Neuman, Y., & Glassner, A. (2006). Identification of informal reasoning fallacies as a function of epistemological level, grade level, and cognitive ability. *Journal of Educational Psychology*, 89, 327–341.

Wellman, H. M., Cross, D., & Watson, J. (2001). Meta-analysis of theory-of-mind development: The truth about false belief. *Child Development*, 72, 655–684.

Wildenger, L., Hofer, B. K., & Burr, J. E. (in press). Epistemological development in very young knowers. In L. D. Bendixen & F. C. Haerle (Eds.), *Personal epistemology in pre-K to 12 education: Theory, research and educational implications*. Cambridge: Cambridge University Press.

Wood, P., & Kardash, C. (2002). Critical elements in the design and analysis of studies of epistemology. In B. K. Hofer & P. R. Pintrich (Eds.), *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 231–260). Mahwah, NJ: Erlbaum.

Wood, P., Kitchener, K. S., & Jensen, L. (2002). Considerations in the design and evaluation of a paper-and-pencil measure of epistemic cognition. In B. K. Hofer & P. R. Pintrich (Eds.), *Personal epistemology: The psychology of beliefs about knowledge and knowing*. Mahwah, NJ: Erlbaum.

Wu, Y. -T., & Tsai, C. -C. (2005). Information commitments: Evaluative standards and information searching strategies in web-based learning environments. *Journal of Computer Assisted Learning*, 21, 374–385.

Youn, I. (2000). The cultural specificty of epistemological beliefs about learning. *Asian Journal of Social Psychology*, 3, 87–105.

Zhang, L. -F. (1999). A comparison of U.S. and Chinese university students' cognitive development: The cross-cultural applicability of Perry's theory. *Journal of Psychology*, 133, 425–439.

Part II
Conceptual and Methodological Issues

Chapter 2
Assessing Teachers' Epistemological and Ontological Worldviews

Gregory J. Schraw and Lori J. Olafson

Abstract This chapter focuses on issues surrounding the assessment of teachers' epistemological and ontological beliefs. Epistemology is the study of beliefs about the origin and acquisition of knowledge. Ontology is the study of beliefs about the nature of reality. Previous research has focused primarily on epistemological beliefs using self-report Likert scales. We discuss several limitations of this approach, including lack of agreement about the dimensionality of epistemological beliefs. Few studies have examined teachers' ontological beliefs, nor have any studies investigated the joint contribution of epistemological and ontological beliefs. The present chapter proposes an integrated, holistic system in which teachers rate themselves using the two-dimensional scale shown in Fig. 2.1. Teachers are asked to situate their epistemological and ontological beliefs on scales ranging from realist to relativist perspectives (see Instructions). We report on the feasibility of using the two-dimensional system, including potential strengths and weaknesses of the system, and directions for future research.

2.1 Introduction

This chapter focuses on issues surrounding the assessment of teachers' epistemological and ontological beliefs. Epistemology is the study of beliefs about the origin and acquisition of knowledge (Hofer, 2004). Ontology is the study of beliefs about the nature of reality (Lincoln & Guba, 2000; Shadish, Cook, & Campbell, 2002). Research over the last three decades has focused primarily on the structure and development of college students' epistemological beliefs (Baxter-Magolda, 1999, 2002; King & Kitchener, 1994; Kuhn, Cheney, & Weinstock, 2000; Perry, 1970; Schommer, 1990; Hofer & Pintrich, 1997). Most studies have measured epistemological beliefs using self-report scales (Hofer, 2000; Schommer, 1990; Schraw et al., 2002), although some have used interview techniques to determine a holistic epistemological stance (Kitchener & King, 1981; Kuhn, 1991; Perry, 1970), open-ended questionnaires

University of Nevada, Las Vegas, USA

M. S. Khine (ed.), *Knowing, Knowledge and Beliefs: Epistemological Studies across Diverse Cultures.*

(Yang, 2005), and content analysis of verbal explanations (Slotta & Chi, 2006) to measure epistemological and ontological assumptions. These studies suggest important differences among students that are related to learning outcomes such as achievement, critical thinking, metacognition, and strategy use (Baxter-Magolda, 2002; Hofer, 2001; Schommer, 1994; Schraw & Sinatra, 2004).

Researchers have only begun a serious investigation of teachers' epistemological beliefs in the last decade. Much of this research has been conducted independently from the research on students' epistemological beliefs. Several recent reviews have tried to connect these bodies of literature (Buehl & Alexander, 2001; Schraw & Olafson, 2002; Woolfolk-Hoy et al., 2006). One problem has been how to conceptualize teachers' epistemological beliefs separate from the previous research on college students' beliefs. Generally speaking, researchers view teachers' epistemological beliefs as being more holistic in nature as compared to research investigating college students' epistemological beliefs, which tended to parcel beliefs into four or five separate dimensions (Hofer, 2000; Schommer-Aikins, 2002). Thus, most studies classify teachers as endorsing a particular epistemological worldview based on interviews (Levitt; 2001; White, 2000; Wilcox-Herzog, 2002) or by match to prototypical worldviews presented in short vignettes (Schraw & Olafson, 2002).

This chapter describes a strategy for simultaneously assessing teachers' epistemological and ontological beliefs. This issue is important for several related reasons. One is that previous research with both students and teachers has confounded different types of beliefs within the general category of epistemological beliefs (Hofer & Pintrich, 1997; Schraw & Olafson, 2002). One goal of the present research is to articulate the difference between epistemological and ontological beliefs for the purpose of assessing different stances on each dimension (Farnham-Diggory, 1994). A second reason is to explore measurement options other than factor analytic rating scales for teachers and students that have been used to self-report personal beliefs on a number of different dimensions. Thus, a second goal of this chapter is to describe an assessment system that can be used with fundamentally different types of beliefs such as epistemology and ontology, yet measure these beliefs using a comparable scale. Using a common metric scale is important in order to determine whether epistemological and ontological beliefs are related to each other, as well as to other variables such as teachers' motivational beliefs (e.g., self-efficacy), curricular choices, and pedagogical strategies used in the classroom.

We emphasize at the outset that our purpose is to propose and describe a new assessment technique that requires additional testing. Nevertheless, we believe there is an acute need to develop a separate conceptual definition of epistemological and ontological beliefs, as well as to develop a methodological strategy for assessing these beliefs in a manner that enables researchers to determine how they are related to many other teacher and classroom variables. In this light, we stress the exploratory, developmental nature of our ongoing research.

This chapter is divided into seven main sections. Section 2.1 reviews and critiques measurement strategies used to assess students' epistemological beliefs in previous research. Section 2.2 reviews and critiques measurement strategies used to assess teachers' epistemological beliefs, noting that previous research has treated students and teachers differently in terms of the conceptual structure of beliefs, as well as strategies for measuring beliefs. Section 2.3 makes an argument for distinguishing between teachers' epistemological and ontological beliefs, and for the importance of a strategy to measure each on the same scale. Section 2.4 describes a technique we refer to as the *four-quadrant scale*, which we describe in detail and present preliminary results based on a sample of 24 practicing teachers. Section 2.5 discusses several potential advantages of the four-quadrant scale. Section 2.6 considers reliability and validity issues, while section 2.7 discusses six questions for future research.

2.2 Previous Research

A number of researchers have attempted to measure epistemological beliefs and world-views using self-report scales or holistic descriptions (Hofer, 2001; Kuhn, 1991; Schommer, 1990; Schraw et al., 2002). We use the term *epistemology* in its broadest sense to refer to a theory of knowledge (Lehrer, 1990; Pollock, 1986). Hofer (2002, p. 4) defines epistemology as being "concerned with the origin, nature, limits, methods, and justification of human knowledge." We use the term *epistemological beliefs* in this article to refer to "beliefs about knowledge and knowledge acquisition." In contrast, we use the term *epistemological worldview* to refer to the collective set of epistemological beliefs that comprise a holistic belief system. We make this distinction because some researchers have attempted to measure epistemological beliefs, while others have attempted to measure epistemological worldviews.

Much of the research over the last two decades has focused on epistemological beliefs, which have been defined by different researchers as beliefs about a specific facet of knowledge such as certainty, complexity, or the source of knowledge and knowing. Schommer (1990) proposed five independent beliefs based on the work of Perry (1970) pertaining to certain knowledge (i.e., absolute knowledge exists and will eventually be known), simple knowledge (i.e., knowledge consists of discrete facts), omniscient authority (i.e., authorities have access to otherwise inaccessible knowledge), quick learning (i.e., learning occurs in a quick or not-at-all fashion), and innate ability (i.e., the ability to acquire knowledge is endowed at birth). Currently, there is debate as to whether Schommer's five beliefs constitute genuine epistemological dimensions (Hofer & Pintrich, 1997). Most researchers agree that beliefs about the certainty and simplicity of knowledge constitute genuine epistemological beliefs. In contrast, many researchers argue that beliefs about innate ability reflect some other, non-epistemological dimension (Hofer & Pintrich, 1997).

Schommer (1990) developed the Epistemological Questionnaire (EQ) to assess the five dimensions described above. The EQ consisted of 62 simple statements that individuals responded to using a five-point Likert scale, indicating the extent to which they agreed or disagreed with the statement. The EQ has been used frequently over the last 15 years by Schommer and other researchers (Chan & Elliott, 2004;

Kardash & Scholes, 1996; Schommer-Aikins, 2002). Results have been somewhat mixed in a variety of ways. First, factor analyses typically reported less than five interpretable factors (Hofer, 2001; Schraw et al., 2002). Second, some analyses have yielded factors with an interpretation that was not predicted by Schommer (1990). For example, a factor might pertain to the source of knowledge or have item loadings that are difficult to interpret in a manner consistent with Schommer's proposed five-factor structure. Third, the factors reported in the analyses often had a small number of items with acceptable factor loadings, and therefore had low or unacceptable reliability coefficients. Fourth, solutions usually explained a relatively small proportion of sample variance (e.g., 20–35%), which raised concerns about the construct validity of the questionnaire.

Schraw et al. (2002) developed a modified version of Schommer's EQ called the Epistemic Beliefs Inventory (EBI) to address these methodological problems. The EBI contained 32 items based on the five factors proposed by Schommer (1990). The EBI typically yielded the five proposed factors; however, reliabilities tended to be low (e.g., .50–.65) and results varied depending on the age and gender of the sample. In addition, like the EQ, the EBI explained a relatively small proportion of sample variation (e.g., usually less than 40%).

Hofer (2001) proposed an alternative four-factor framework and developed an instrument called the Epistemological Beliefs Questionnaire (EBQ) to assess these factors. She proposed four factors, which were subsumed under two general dimensions referred to as *the nature of* knowing and *the process of* knowing. The former refers to what knowledge is presumed to be, while the latter refers to how one comes to know and understand knowledge. The "nature" dimension included two factors called certainty of knowledge (i.e., the degree to which one sees knowledge as fixed versus fluid and changeable) and simplicity of knowledge (i.e., the degree to which knowledge is viewed as individual facts versus complex, interrelated concepts). The "process" dimension included two factors called source of knowledge (i.e., the extent to which credible knowledge is self- or other generated) and justification of knowing (i.e., the rules and criteria that individuals use to evaluate knowledge claims).

Hofer (2001) reported four empirically derived factors that differed somewhat from the four proposed factors described above. Her four observed factors included certainty of knowledge, source of knowledge, justification, and attainment of truth. A "simplicity of knowledge" factor was not observed, whereas an "attainment of truth" factor was observed. The attainment of truth factor was interpreted as the extent to which experts can attain deep knowledge (i.e., "truth") within their area of expertise. Like the EQ and EBI, the EBQ explained approximately 45% of sample variance, had several factors with few items that loaded satisfactorily, and had factors with low reliability coefficients.

Thus far, self-report instruments that have been developed to assess multiple epistemological beliefs have had mixed success. One important contribution of this research is that there has been a great deal of productive discussion regarding the set of constructs that comprise the domain of epistemological beliefs (Buehl & Alexander, 2001; Hofer, 2001, 2004; Hofer & Pintrich, 1997; Olafson & Schraw, 2002; Schraw & Sinatra, 2004). These discussions are crucial to mapping the possible domain of epistemological beliefs both conceptually and methodologically. A second contribution has been the preliminary findings concerning the relationships among epistemological beliefs and a variety of outcomes variables such as age, education level, gender, moral reasoning skills, and academic achievement.

2.3 Four Measurement Concerns

Notwithstanding the contributions of current instruments, there are a number of ongoing concerns that encouraged us to explore other assessment strategies. One concern is that existing self-report instruments have not agreed on what should and can be measured by these instruments. Specifically, there is disagreement about how many separate epistemological beliefs should be included in the general domain of epistemological beliefs. For example, while most researchers agree on beliefs related to the complexity and certainty of knowledge, there is less agreement regarding the source and origin of knowledge, and still less agreement regarding issues related to the attainment of truth. Neither is it well understood how these separate beliefs are interrelated. Some researchers have argued that epistemological beliefs are unrelated, while others have argued that separate beliefs (Schommer-Aikins, 2002; Schommer, 1990) are related to a broader epistemological meta-construct (Schraw & Olafson, 2002). A closely related issue is whether epistemological beliefs are unique to each domain (Hofer, 2000, 2001) or common across domains (Olafson & Schraw, 2006).

A second concern is the low predictive validity between epistemological factors used in ongoing research and various outcome variables such as academic achievement. For example, correlations between epistemological beliefs and academic performance typically account for 3–8% of sample variance in the outcome measure (Hofer, 2001). Similar findings have been reported for reading (Schommer, 1994) and problem solving (Schommer et al., 1992). The fact that beliefs are not correlated highly with academic outcomes may be due to low reliability and restriction of range in the epistemological measurements, or to the possibility that sophisticated personal beliefs have little effect on day-to-day academic outcomes. In any case, findings would be more useful and generalizable if self-reported epistemological factors explained larger proportions of variation in salient outcomes such as academic achievement.

A third concern is that self-report instruments attempt to measure narrowly defined epistemological beliefs rather than holistic epistemological worldviews that are assumed to represent an integrated set of beliefs about knowledge. A number of studies have assessed holistic epistemological worldviews based on self-report measures (White, 2000), interviews in which individuals reason about complex problems (King & Kitchener, 1994; Kuhn, 1991), or rate the degree to which they endorse different epistemological worldviews based on written vignettes (Schraw & Olafson, 2002). These studies have linked holistic epistemological worldviews to complex behaviors such as argumentative reasoning (Kuhn, 1991) and teachers' curricular and instructional choices (White, 2000). One potential advantage of this approach is that researchers or participants can identify a multifaceted set of beliefs that describes the epistemological milieu that guides the individual's thought and professional choices. Using a broad rather than narrow aperture to examine epistemological beliefs may provide a richer description of a person's epistemological worldview. In addition, it is important to note that measuring epistemological beliefs via separate self-reported beliefs versus a holistic stance are not mutually exclusive measurement strategies. Schraw and Olafson (2002) found significant relationships between three different holistic epistemological stances and the five epistemological beliefs as measured by the Epistemological Belief Inventory (EBI). Using the two strategies simultaneously to cross-validate one another may enhance future research endeavors.

A fourth concern, and one of special importance to this chapter, is that previous research has focused exclusively on epistemological beliefs without also considering what we refer to henceforth as ontological beliefs. Epistemological beliefs have been defined in the literature as beliefs about the origin and nature of knowledge. For present purposes, we define ontological beliefs as *beliefs about the nature of reality* (Lincoln & Guba, 2000; Mertens, 2005). The distinction between epistemological and ontological beliefs and/or worldviews is an extremely important one for both conceptual and methodological reasons. From a conceptual standpoint, philosophers of science have traditionally distinguished between the two and argued that both contribute to the way in which social scientists view and conduct research and construe theories of metascience (Kuhn, 1962; Lakatos, 1978; Popper, 1959; Shadish et al., 2002). From a methodological perspective, it is unclear how epistemological and ontological beliefs are related to one another, to student achievement, or to teachers' instructional practices.

We believe it is crucial to measure both epistemological and ontological beliefs and to do so in a manner in which each type of belief is assessed on the same measurement scale. The focus of this chapter is on describing such an approach and summarizing the advantages of using this strategy. As noted earlier, using the strategy described later does not preclude other measurement strategies; thus, we believe that it is best to use multiple measurement strategies when assessing personal beliefs.

2.4 The Four-quadrant Scale

We describe a new strategy for assessing epistemological and ontological beliefs using a common measurement scale. We refer to this as the *four-quadrant scale* because there are four distinct quadrants into which a person can be classified based on self-report of external judgment by a researcher. This approach is an application of the issues discussed by Shadish et al. (2002), regarding differences in individual beliefs about the theory and conduct of social science research. We begin with definitions of epistemological and ontological beliefs based on Shadish et al. (2002), then describe the structure of the four-quadrant scale, and summarize some pilot findings using the scale.

2.4.1 Definitions

We define epistemological beliefs as our collective beliefs about the origin and acquisition of knowledge. We assume that different individuals hold different epistemological beliefs, both in terms of the content of their beliefs, as well as the relative sophistication of beliefs. We do not assume that these beliefs are necessarily explicit and subject to reflection, although they may be, and hopefully become more explicit and structured as individuals develop expertise within a domain and become more sophisticated thinkers (Cunningham & Fitzgerald, 1996; Hofer & Pintrich, 1997; Kuhn, 1999; Prawat, 1992). We define ontological beliefs as beliefs about the nature of reality. We assume that different individuals hold different beliefs and that these beliefs differ with respect to their explicitness and sophistication. We make no assumption currently about whether these beliefs are related or how they develop.

As noted above, previous research has attempted to identify and measure separate epistemological beliefs (Hofer, 2000; Schommer, 1990; Schraw et al., 2002). For present purposes, we focus on holistic epistemological worldviews rather than individual epistemological beliefs. Schraw and Olafson (2002) used the term *epistemological worldview* to refer to collective beliefs about the nature and origin of knowledge. Researchers have attempted to measure epistemological worldviews using verbal explanations (Kuhn, 1991), written vignettes (Schraw & Olafson, 2002), and open-ended responses (Yang, 2005). Similarly, we focus on ontological world-views rather than ontological beliefs. Several studies have measured ontological beliefs using think-alouds, though none have examined teachers' ontological beliefs, or the relationship between epistemological and ontological beliefs (Slotta & Chi, 2006).

2.4.2 Creating the Scale

Shadish et al. (2002) provided a detailed discussion of the role of epistemological and ontological beliefs with respect to the process of scientific inquiry. They suggested that each type of belief exists on a continuum that ranges from realist to relativist endpoints. A *realist* believes that entities or phenomena (e.g., knowledge or physical matter) exist and can be understood and explained to some degree, even if experts do not currently understand the phenomenon that is being considered. For example, a physicist may believe that "dark matter" exists in open space even though it is currently undetectable. The basis for their belief may be theoretical (e.g., mathematical models), partial empirical evidence, or faith. In contrast, a *relativist* believes that entities may exist in an ever-changing manner (e.g., the changing nature of human rights), or that we can never know with certainly whether something exists (e.g., that God exists). From an educational perspective, a teacher with a realist world-view would be more likely to endorse a belief in a universal curriculum that is transmitted to students via a knowledgeable teacher; whereas a relativist would be more likely to endorse a constructivist view that each student constructs knowledge that is relevant to him or her, given help from the teacher (Brownlee & Berthelsen, 2006; Chan & Elliott, 2004).

We wish to elaborate on two assumptions made by Shadish et al. (2002) that we concur with. One is that beliefs occur on a continuum and may change over time from realist to relativist or the reverse. A second is that the epistemological beliefs and worldviews held by an individual may be at one point on the continuum even though the same individual's ontological beliefs and worldview may be at a different point on the continuum. Thus, a person's commitment to a realist or relativist point of view may change over time and differ across epistemological and ontological dimensions. We assume that beliefs are changeable due to a variety of factors, but especially education, explicit inquiry, collaborative discussion, and developing critical reasoning skills (Kuhn, 1999; White & Frederiksen, 2005). We also assume that realist world-views are related to traditional teaching practices, while relativist worldviews are related to constructivist practices (Brownlee & Berthelsen, 2006; Levitt, 2001; Olafson & Schraw, 2002; White, 2000).

Our goal was to develop an assessment tool that allowed individuals to situate their epistemological and ontological beliefs in an easy to understand manner. Two steps were necessary to do so. First, we needed to create a set of instructions for how to identify one's epistemological and ontological worldviews. This seemed especially important for individuals unfamiliar with these terms or who had not considered their worldviews explicitly. Second, we needed to create an easy to use scale on which individuals could rate their worldviews. We created the instructions shown in Table 2.1 that were used in a pilot study of the four-quadrant scale with practicing teachers. The purpose of this study was to ask teachers to situate their epistemological and ontological worldviews using the four-quadrant scale.

The four-quadrant scale partitions epistemological and ontological worldviews into two axes at right angles to each other that range from realist to relativist on each axis. This yields four quadrants in which a person can rate oneself as realist-realist, realist-relativist, relativist-realist, or relativist-relativist. Individuals are able to select a point in any area of the four-quadrant array that best corresponds to their personal epistemological and ontological worldviews about teaching.

Participants read general instructions and summaries of epistemological and ontological realist and relativist positions shown in Table 2.1. They next considered their own worldviews and then rated themselves on the four-quadrant scale shown in Fig. 2.1 by placing an X in one of the four quadrants that best corresponded to their personal epistemological and ontological worldviews.

Several comments are warranted regarding the rating sheet in Fig. 2.1. First, the four quadrants are shown in a box-shaped figure that is subdivided into four

Table 2.1 Instructions to participants

Instructions

We want you to rate and explain your epistemological and ontological worldviews. Please read the following description of terms used in this study. Then indicate with an "X" where you would place yourself in the four quadrants shown on the Rating Sheet. To make your X, find the point where your ratings intersect on the epistemology dimension and the ontology dimensions.

Please note that the descriptions provided below represent endpoints on each of the scales. Your own beliefs may lie anywhere between these two endpoints. You may use any part of the four quadrant area.

After you make your rating, please describe in as much detail as possible on the Explanation Sheet your reasoning for your self-rating.

Epistemology

Epistemology is the study of what can be counted as knowledge, where knowledge is located, and how knowledge increases. The personal epistemology of teachers is characterized by a set of beliefs about learning and the acquisition of knowledge that drives classroom instruction.

Epistemological Realist

An epistemological realist would believe that there is an objective body of knowledge that must be acquired. From a teacher's perspective, this position would hold that curriculum is fixed and permanent and focuses on fact-based subject matter. An epistemological realist might believe the following:

- There are certain things that students simply need to know.
- I am teaching information that requires memorization and mastery.
- There are specific basic skills that need to be mastered.

Epistemological Relativist

An epistemological relativist would describe curriculum as changing and student-centered. Problem-based or inquiry curricula are examples at the other end of the continuum from a perspective of a one-size-fits-all curriculum. One of the central features of curriculum from this position is the notion that curriculum is not fixed and permanent. An epistemological relativist might agree with the following statements:

- The things we teach need to change along with the world.
- The content of the curriculum should be responsive to the needs of the community.
- It is useful for students to engage in tasks in which there is no indisputably correct answer.
- Students design their own problems to solve.

Ontology

Ontology is the study of beliefs about the nature of reality. The personal ontology of teachers is characterized by a set of beliefs regarding whether students share a common reality and what a classroom reality should look like.

Ontological Realist

A teacher who is an ontological realist assumes one underlying reality that is the same for everyone. Instructionally, this means that all children should receive the same type of instruction at the same time regardless of their individual circumstances and context. An ontological realist would agree with the following:

- Student assignments should always be done individually.
- It is more practical to give the whole class the same assignment.
- The teacher must decide on what activities are to be done.

(continued)

Table 2.1 (continued)

Ontological Relativist
An ontological relativist assumes that different people have different realities. From an instructional perspective, teachers are seen as collaborators, co-participants, and facilitators of learning who work to meet the individual needs of students. Instructional practices are less teacher-directed, such as: • Students need to be involved in actively learning through discussions, projects, and presentations. • Students work together in small groups to complete an assignment as a team.

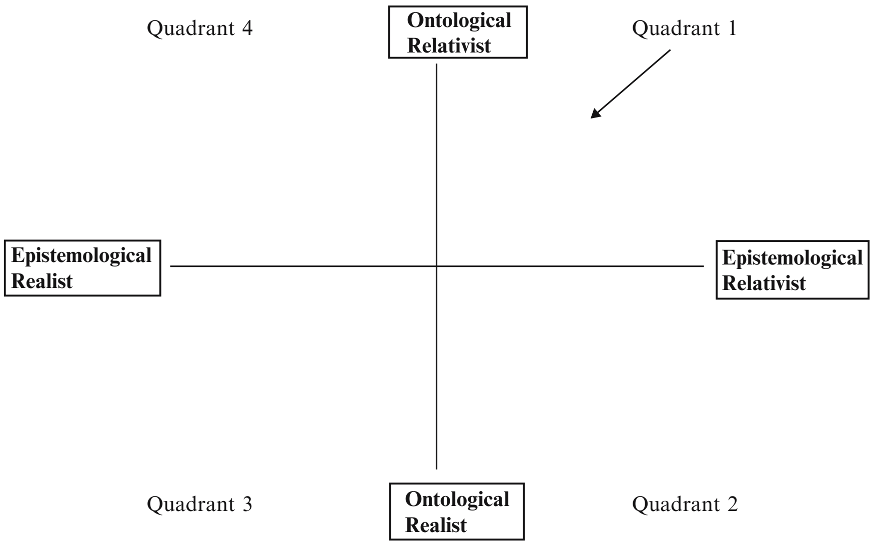


Fig. 2.1 The four-quadrant scale

subsections. It is unclear presently whether the outside perimeter to the box should or should not be present. We note that in the pilot study, where the perimeter was not included, participants sometimes placed their X outside the boundary of the perimeter. Second, Fig. 2.1 shows the upper right-hand quadrant as *quadrant 1*. The lower right-hand corner was designated as quadrant 2, with quadrants 3 and 4 occurring in a counterclockwise manner. The labels *quadrant 1–4* did not appear on the rating sheet used in the pilot study, but was used as an interpretative convenience. In contrast, the four labels indicating epistemological and ontological realism/relativism were included as anchor points in the pilot study. Third, the figure used in the pilot study used axes of equal length. We used a scale with two right-angle axes of 150 mm length (i.e., approximately 6 in. in length). A four-quadrant scale of these dimensions fits onto a page well and seems large enough to allow raters a wide selection of possible choices. The location of each participant's

X can be scored on a scale of 1–150 using a ruler scaled in millimeters. For example, an X in the extreme upper right corner would be scored as a 150 on the epistemological axis and a 150 on the ontological axis. In contrast, an X at the intersection point of the two axes would be scored as a 75 on each dimension. This enables researchers to assess both types of worldviews on the same scale.

2.5 Pilot Study

Twenty-four practicing teachers participated in the study. All participants were enrolled in a graduate level course in curriculum and instruction at a large western university and working toward a graduate degree in education. Half the participants were enrolled in a M.Ed. program, while half were enrolled in a Ph.D. program. The average age was 38.2 years. Teachers had between two and 23 years teaching experience.

Participants took part in the pilot study as volunteers during their regularly scheduled class. The four-quadrant scale was administered by their classroom instructor. Participants were not allowed to discuss their worldviews with others prior to making their ratings; however, the remainder of their class was devoted to discussing and comparing worldviews after completing their rating and justification. Individuals read instructions and completed the rating sheet. This required approximately 5 min. Individuals next received 10 min to provide a written explanation of their epistemological and ontological worldviews.

2.6 Preliminary Findings and Comments

Visual results are shown in Fig. 2.2. Several preliminary findings were germane to the development and piloting of the four-quadrant scale. One finding was that participants were able to complete the four-quadrant scale quickly and efficiently. Individuals reported that the instructions were easy to understand and that they had a good idea of what they were expected to do. The instructions shown in Table 2.1 are appropriate for teachers' worldviews, but would need to be modified to use the four-quadrant scale with other populations such as educational researchers, historians, or philosophers.

A second finding was that most respondents were in quadrants 1 and 4, with only two respondents in quadrant 3, and none in quadrant 2. Approximately 22 of the 24 participants rated themselves as ontological relativists of some degree. In contrast, approximately 45% of respondents rated themselves as epistemological realists of some degree. A content analysis of written explanations suggested that individuals in quadrant 3 were more likely to endorse traditionalist views, which included support for a universal curriculum based on core knowledge and skills, whereas individuals in quadrant 1 supported constructivist views, which emphasize

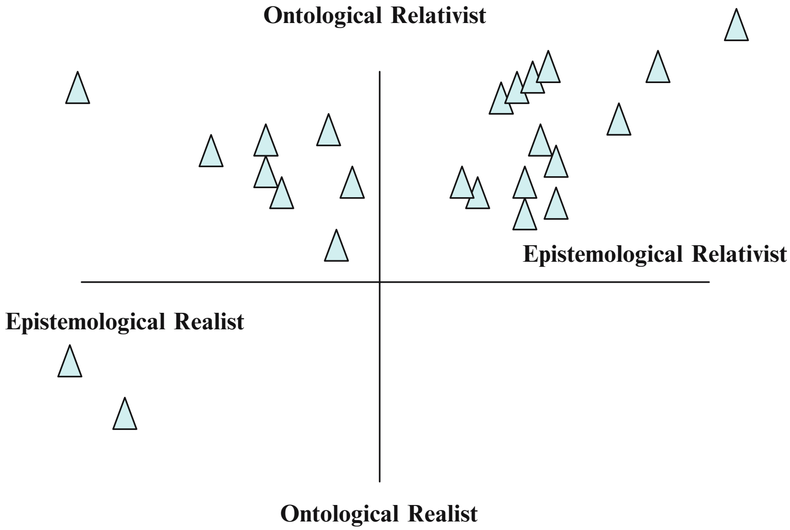


Fig. 2.2 Visual results from pilot study

the role of student inquiry, collaboration, and self-learning. These results are consistent with several recent studies that have compared differences between prototypical realist and relativist worldviews (Brownlee & Berthelsen, 2006; Chan & Elliott, 2004; Schraw & Olafson, 2002).

A third finding was that we observed a statistically significant positive relationship between the epistemological and ontological dimension, $r = .45$, $p < .05$, using a two-tailed test. We computed this correlation by assigning two separate scores to each teacher's rating. One score was scaled from 1–150 on the epistemological dimension, while the second score was scaled from 1–150 on the ontological dimension. The finding of a significant positive correlation between the two suggests that realist beliefs on one dimension are associated with realist beliefs on the second dimension. However, we emphasize that the present sample was highly selective in that it included experienced teachers enrolled in advanced graduate courses. This outcome may be unrepresentative of a larger, more diverse sample.

Overall, the pilot study indicated that the four-quadrant scale can be used with teachers in a quick and straightforward manner to assess their epistemological and ontological worldviews. Preliminary findings suggested that different worldviews may correspond to differences in the beliefs that teachers hold about curriculum, and pedagogy. Although not part of the pilot study, teachers' worldviews may be related to other classroom factors such as assessment and discipline practices (Brownlee & Berthelsen, 2006; Olafson & Schraw, 2006, 2002; White, 2000; Wilcox-Herzog, 2002).

2.6.1 Potential Strengths of the Four-quadrant Scale

The pilot study described earlier suggests that the four-quadrant scale provides a viable measure of teachers' worldviews. There are several potential advantages of the four-quadrant scale compared to previous assessment strategies. One of the system's most important advantages is that it enables researches to distinguish clearly between epistemological and ontological worldviews. This distinction is extremely important because the two belief systems represent different assumptions on the part of teachers that may affect classroom practices in different ways. The pilot study yielded a correlation between the two dimensions of r = .45, suggesting that the two world-views may be correlated moderately under certain circumstances. Future studies should be conducted to examine in more detail when the two dimensions are and are not interrelated.

A second advantage is that the four-quadrant scale is quick and easy to use. Data can be collected in 10–20 min, including written justifications from teachers (or other research participants) regarding that self-ratings. Data can be scored and interpreted quickly and without in-depth technical expertise. In contrast, survey results typically need to be scored, tabulated, and evaluated using complex statistical procedures such as factor analysis. Similarly, verbal reports (Slotta & Chi, 2006), open ended questionnaires (Yang, 2005), or holistic ratings based on written essays (Kuhn, 1991) are time consuming and subject to differences in judges who evaluate the responses. Given additional validation research on the four-quadrant scale, we believe that it offers researchers a quick and efficient way to collect important information about teachers' worldviews that does not preclude other data collection strategies such as surveys and interviews.

A third advantage of the four-quadrant scale is that it provides measures of epistemological and ontological worldviews on the same metric scale. We used a 150 mm scale in the pilot study for each of the two dimensions because it seemed visually optimal. Future studies may choose to compare different scaling systems to determine whether different scales increase or decrease the sensitivity of the method. Nevertheless, the four-quadrant scale as described earlier enables researchers to make meaningful comparisons given that the epistemological and ontological dimensions share the same scale. This should facilitate both quantitative (e.g., correlation and regression analyses) and qualitative comparisons (e.g., differences across dimensions regarding a commitment to relativism).

A fourth advantage is that the system enables researchers to compare teachers in each of the four quadrants to those in other quadrants on critical variables such as gender, years of experience, curricular and instructional practices, self-efficacy beliefs, as well as a variety of other variables. Presently it is unclear whether differences within a quadrant are as important as differences between quadrants. Future research should investigate how seemingly major differences such as those between extreme points in quadrants 1 and 3 are related to teaching practice and student achievement.

2.6.2 Reliability and Validity

Currently there is no data to address the reliability or validity of the four-quadrant scale, although such data can be collected in a straightforward manner. It is not possible to compute the internal consistency of the four-quadrant self-rating given that it is a single, onetime event. However, it is possible to compute test-retest reliability on a sample. We would expect this index to be quite high over a short period of time such as 2–4 weeks.

Both construct and criterion-related validity are important aspects of any assessment instrument. Construct validity refers to the degree to which an inference is warranted about the phenomenon of interest within a particular sampling context. Construct validity typically has been determined using correlational techniques in which the construct of interest (e.g., epistemological worldviews) are related to similar and dissimilar constructs. Positive correlations with similar constructs (e.g., ontological worldviews, different measures of epistemological worldviews, or measures of critical thinking) constitute convergent validity evidence; whereas negative correlations with dissimilar constructs (e.g., support for book censorship) constitute discriminant validity (Mertens, 2005). A strong case for construct validity is made when a researcher selects several similar and dissimilar constructs, predicts which will be positively and negatively correlated with the construct of interest, and those predictions are supported empirically. Strong support for the four-quadrant scale would be obtained if an individual completed the four-quadrant approach, as well as other measures of epistemological beliefs such as the Epistemological Questionnaire (Schommer, 1994) and the self-report vignettes used by Schraw and Olafson (2002), and the individual scored similarly on all three measures. Currently, we are engaged in several research studies intended to provide evidence in support of the four-quadrant scale's construct validity.

Criterion-related validity refers to the degree to which the construct of interest is related to other constructs such as gender, education, academic achievement, etc. Two types of criterion-related validity are useful to researchers, including concurrent and predictive validity. Concurrent validity occurs when the construct of interest is related to a different construct such as academic achievement when measured at the same point in time. Predictive validity occurs when the construct of interest is related to a different construct of interest school at some point in the future. We anticipate that teachers who score higher on the epistemological and ontological dimensions (i.e., endorse a strong relativist view) would tend to have more education, support constructivist pedagogy, and employ a more diverse curriculum than teachers who scores low on the two dimensions.

We believe that the four-quadrant scale should be validated using other available measure of epistemological beliefs (Hofer, 2001; Schommer, 1994; Schraw et al., 2002) and worldviews (Schraw & Olafson, 2002), measures of teachers' curricular and instructional choices and practices, measures teacher beliefs such as self-efficacy and goal orientations, and measures of student outcomes such as interest, motivation, and achievement.

2.7 Questions for Future Research

A number of questions for future research are related to the development of the four-quadrant scale. We focus on six of these questions. One is a more detailed description and analysis of each of the four quadrants. We assume that each quadrant represents a fundamentally different perspective on knowing and reality. Some of these positions, such as individuals in quadrants 1 and 3, seem to be highly consistent in that individuals endorse either universally realist of relativist worldviews. In contrast, individuals in quadrant 3 seem to hold perhaps inconsistent beliefs in that they endorse a relativist ontology, coupled with a realist epistemology. Additional qualitative analyses of the four quadrants are needed to understand the thinking that supports each of these worldviews, as well as the degree to which individuals reconcile their beliefs on the epistemological and ontological dimensions.

A second is the extent to which the type and amount of preservice teacher education training affects epistemological and ontological worldviews (Britzman, 2000; Brownlee et al., 2001). Few studies have examined preservice teachers' epistemological worldviews in detail, and none that we know of have examined ontological beliefs. It is possible that preservice training has little effect on preservice teachers' worldviews. However, it is likely that the type of pre-service training a student receives affect his or her beliefs differently (Joram & Gabriele, 1998; Laplante, 1997). One possibility is that traditional classroom-based preservice training has a smaller effect than field-based apprenticeships (Olafson & Schraw, 2002; White, 2000).

A third question concerns teacher development over time (Garet et al., 2001; Kuhn et al., 2000). Previous research suggests that teachers develop over time regarding teaching practices and that their beliefs change as part of their development (Brownlee et al., 2001; Gill et al., 2004; Woolfolk-Hoy et al., 2006). Very little is known currently regarding the development of teachers' epistemological and ontological beliefs (Bendixen, 2002). One issue is whether the two beliefs develop in tandem or follow separate trajectories. A second issue is the general trend in development. We assume that beliefs become more relativist over time, but may become stable at some point, or perhaps move from a relativist to realist worldviews past a certain number of years of experience (Lieberman, 1995; Reybold, 2001). Cross sectional studies would help address these questions, although longitudinal studies would be especially useful for understanding the development of beliefs.

A fourth question relates to understanding the differences within and among the four quadrants shown in Fig. 2.1. Teachers within a quadrant may differ from other teachers within the same quadrant. Presently, it is unclear whether these differences matter in terms of type or degree. Teachers also differ from teachers in other quadrants, and these differences are assumed to be much more substantial in nature. For example, teachers in quadrant 1 tend to endorse relativist views on both dimensions, whereas teachers in quadrant 3 tend to endorse realist views on both dimensions. Future research should help to develop a prototype teacher for each of the four quadrants and to compare systematically the differences among the four quadrants. We assume that teachers in the four quadrants differ in many regards, including beliefs and practices about curriculum, pedagogy, assessment strategies, and classroom management (Borko & Putnam, 1996; Johnston et al., 2001; Schraw & Olafson, 2002).

A fifth question concerns the relationship between teachers' beliefs and practices (Wilcox-Herzog, 2002). At least two critical issues are in need of research. One is the separate and interactive rolls of epistemological and ontological beliefs on teachers' curricular and instructional choices. Previous research suggests that teachers with high versus low self-efficacy adopt different instructional and classroom management strategies (Calderhead, 1996; Goddard et al., 2000; Pajares, 1996; Woolfolk-Hoy & Burke-Spero, 2005). Several recent studies also suggest that different epistemological beliefs lead to different teaching practices (Brownlee & Berthelsen, 2006; Chan & Elliott, 2004; Yang, 2005). We anticipate that teachers with strong relativist worldviews on either of the epistemological or ontological dimensions are more likely to conduct a student-centered classroom (Brownlee & Berthelsen, 2006; Hashweh, 1996). A second issue is the extent to which teachers' epistemological and ontological beliefs are related to student engagement and achievement. We assume that relativist teachers conduct a more constructivist oriented classroom that is more likely to engage students and promote deeper learning (Holt-Reynolds, 2000).

A sixth question concerns ethnic and cultural differences among teachers' epistemological and ontological beliefs. Previous research suggests that beliefs differ as a function of academic discipline (Buehl & Alexander, 2001; Hofer, 2001; Jehng et al., 1993) and years of teaching experience (Woolfolk-Hoy et al., 2006). Very little is known currently regarding cross-cultural differences in teachers' beliefs, but especially epistemological and ontological beliefs, which have received less attention from researchers, although existing studies report important differences (Ceci & Roazzi, 1994). We conjecture that cultural differences occur, but that highly effective teachers tend to adopt relativist views of learning regardless of cultural differences (Brownlee & Berthelsen, 2006; Chan & Elliott, 2004). This hypothesis remains to be tested.

2.8 Summary

The main goal of this chapter was to describe a new measurement strategy that enables researchers to examine the separate and combined effects of teachers' epistemological and ontological beliefs. We summarized previous research, discussed the pros and cons of existing assessment strategies, and made a case for some of the advantages of the four-quadrant scale. The two main advantages are that the four-quadrant scale incorporates ontological as well as epistemological worldviews, and also provides a format for assessing epistemological and ontological worldviews using the same scale metric. For this reason, both teachers' and students' epistemological and ontological worldviews can be compared in a more parsimonious manner.

Our proposed system requires a great deal of validation research. We outlined several of the critical issues involved in establishing the construct and criterion-related validity of an interpretation based on the four-quadrant scale. Validation studies should occur early in the overall research program to assure that the four-quadrant scale is trustworthy. Given support for the four-quadrant scale, a variety of important research questions can be addressed, including the development of beliefs, and the relationship among beliefs, worldviews, and teaching practices.

Consistent with the main theme of the present volume, we encourage researchers to develop profiles of prototypical teachers in each of the four quadrants and to compare these profiles across cultures and different school environments. It is unclear presently what cultural and environmental factors shape teachers' beliefs, and how beliefs relate to teaching practices in different cultures. One possibility is that two teachers with highly similar worldviews adopt different teaching practices, in part due to cultural mandates and expectations. Of special interest is whether epistemological and ontological beliefs affect teaching practices to the same degree across cultures, or are equally permeable to change through education and experience.

References

Baxter-Magolda, M. B. (1999). The evolution of epistemology: Refining contextual knowing at twenty something. *Journal of College Student Development*, 36, 205–216.

Baxter-Magolda, M. B. (2002). Epistemological reflection: The evolution of epistemological assumptions from age 18 to 30. In B. Hofer & P. R. Pintrich (Eds.), *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 89–102). Mahwah, NJ: Erlbaum.

Bendixen, L. D. (2002). A process model of epistemic belief change. In B. K. Hofer & P. R. Pintrich (Eds.), *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 191–208). Mahwah, NJ: Erlbaum.

Borko, H., & Putnam, R. T. (1996). Learning to teach. In D. C. Berliner & R. C. Calfee (Eds.), *Handbook of educational psychology* (pp. 673–708). New York: MacMillan.

Britzman, D. (2000). Teacher education in the confusion of our times. *Journal of Teacher Education*, 51(3), 200–205.

Brownlee, J., Purdie, N., & Boulton-Lewis, G. (2001). Changing epistemological beliefs in pre-service teaching education students. *Teaching in Higher Education*, 6, 247–268.

Brownlee, J., & Berthelsen, D. (2006). Personal epistemology and relational pedagogy in early childhood teacher education programs. *Early Years*, 26, 17–29.

Buehl, M. M. & Alexander, P. A. (2001). Beliefs about academic knowledge. *Educational Psychology Review*, 13, 385–418.

Calderhead, J. (1996). Teachers: Beliefs and knowledge. In D. C. Berliner & R. C. Calfee (Eds.), *Handbook of educational psychology* (pp. 709–725). New York: Macmillan.

Ceci, S. J., & Roazzi, A. (1994). The effects of context on cognition: Postcards from Brazil. In R. J. Sternberg, & R. K. Wagner (Eds.), *Mind in context: Interactionist perspectives on human intelligence* (pp. 74–104). Cambridge, England: Cambridge University Press.

Chan, K., & Elliott, R. G. (2004). Relational analysis of personal epistemology and conceptions about teaching and learning. *Teaching and Teacher Education*, 20, 817–831.

Cunningham, J. W., & Fitzgerald, J. (1996). Epistemology and reading. *Reading Research Quarterly*, 31, 36–60.

Farnham-Diggory, S. (1994). Paradigms of knowledge and instruction. *Review of Educational Research*, 64, 463–477.

Garet, M. S., Porter, A. C., Desimone, L., Birman, B. F., & Yoon, K. S. (2001). What makes professional development effective? Results from a national sample of teachers. *American Educational Research Journal*, 38, 915–945.

Gill, M. G., Ashton, P. T., & Algina, J. (2004). Changing preservice teachers' epistemological beliefs about teaching and learning I in mathematics: An intervention study. *Contemporary Educational Psychology*, 29, 164–185.

Goddard, R. D., Hoy, W. K., & Hoy, A. W. (2000). Collective teacher efficacy: Its meaning, measure and impact on student achievement. *American Educational Research Journal*, 37, 479–507.

Hashweh, M. Z. (1996). Effects of science teachers' epistemological beliefs in teaching. *Journal of Research in Science Teaching*, 33, 47–63.

Hofer, B. K. (2000). Dimensionality and disciplinary differences in personal epistemology. *Contemporary Educational Psychology*, 25, 378–405.

Hofer, B. (2001). Personal epistemology research: Implications for learning and teaching. *Educational Psychology Review*, 13, 353–384.

Hofer, B. (2002). Epistemological world views of teachers: From beliefs to practices. *Issues in Education: Contributions from Educational Psychology,* 8(2), 167–173.

Hofer, B. (2004). Exploring the dimensions of personal epistemology in differing classroom contexts: Student interpretations during the first year of college *Contemporary Educational Psychology*, 29, 129–163.

Hofer, B. K., & Pintrich, P. R. (1997). The development of epistemological theories: Beliefs about knowledge and knowing and their relation to learning. *Review of Educational Research*, 67, 88–140.

Holt-Reynolds, D. (2000). What does the teacher do? Constructivist pedagogies and prospective teachers' beliefs about the role of the teacher. *Teaching and Teacher Education*, 16, 21–32.

Jehng, J. J., Johnson, S. D., & Anderson, R. C. (1993). Schooling and student's epistemological beliefs about learning. *Contemporary Educational Psychology*, 18, 23–35.

Johnston, P., Woodside-Jiron, H., & Day, J. (2001). Teaching and learning literate epistemologies. *Journal of Educational Psychology*, 93(1), 223–233.

Joram, E., & Gabriele, A. J. (1998). Preservice teachers' prior beliefs: Transforming obstacles into opportunities. *Teaching and Teacher Education*, 14, 175–191.

Kardash, C. M., & Scholes, R. J. (1996). Effects of preexisting beliefs, epistemological beliefs, and need for cognition on interpretation of controversial issues. *Journal of Educational Psychology*, 88, 260–271.

King, P. M., & Kitchener, K. S. (1994). *Developing reflective judgment*. San Francisco, CA: Jossey-Bass.

Kitchener, K. S., & King, P. A. (1981). Reflective judgment: Concepts of justification and their relationship to age and education. *Journal of Applied Developmental Psychology*, 2, 89–116.

Kuhn, T. S. (1962). *The structure of scientific revolutions*. Chicago, IL: University of Chicago Press.

Kuhn, D. (1991). *The skills of argument*. New York: Cambridge University Press.

Kuhn, D. (1999). A developmental model of critical thinking. *Educational Researcher*, 28, 16–26.

Kuhn, D., Cheney, R., & Weinstock, M. (2000). The developmental of epistemological understanding. *Cognitive Development*, 15, 309–328.

Lakatos, I. (1978). *The methodology of scientific research programmes*. Cambridge, England: Cambridge University Press.

Laplante, B. (1997). Teachers' beliefs and instructional strategies in science: Pushing analysis further. *Science Instruction*, 81, 277–294.

Lehrer, K. (1990). *Theory of knowledge*. San Francisco, CA: Westview Books.

Levitt, K. E. (2001). An analysis of elementary teachers' beliefs regarding the teaching and learning of science. *Science Education*, 86, 1–22.

Lieberman, A. (1995). Practices that support teacher development: Transforming conceptions of professional development. *Phi Delta Kappan*, April, 591–596.

Lincoln, Y. S., & Guba, E. G. (2000). Paradigmatic controversies, contradictions, and emerging confluences. In N. K. Denzin & Y. S. Lincoln (Eds.), *Handbook of qualitative research* (2nd edition, *pp*. 163–188). Thousand Oaks, CA: Sage Publications.

Mertens, D. M. (2005). *Research and evaluation in education and psychology: Integrating diversity with quantitative, qualitative, and mixed methods* (2nd edition). Thousand Oaks, CA: Sage Publications.

Olafson, L. J., & Schraw, G. (2002). Some final thoughts on the epistemological melting pot. *Issues in Education*, 8, 233–246.

Olafson, L. J., & Schraw, G. (2006). Teachers' beliefs and practices within and across domains. *International Journal of Educational Research*, 45, 71–84.

Pajares, F. (1996). Self-efficacy beliefs in academic settings. *Review of Educational Research*, 66, 543–578.

Perry, W. G., Jr. (1970). *Forms of intellectual and ethical development in the college years*. New York: Academic Press.

Pollock, J. L. (1986). *Contemporary theories of knowledge*. Savage, MD: Rowman & Littlefield.

Popper, K. R. (1959). *The logic of scientific discovery*. London: Hutchinson.

Prawat, R. S. (1992). Teachers' beliefs about teaching and learning: A constructivist perspective. *American Journal of Education*, 35, 354–395.

Reybold, L. E. (2001). Encouraging the transformation of personal epistemology. *Qualitative Studies in Education*, 14, 413–428.

Schommer, M. (1990). Effects of beliefs about the nature of knowledge on comprehension. *Journal of Educational Psychology*, 82, 498–504.

Schommer, M. (1994). Synthesizing epistemological belief research: Tentative understandings and provocative confusions. *Educational Psychology Review*, 6, 293–320.

Schommer-Aikins, M. (2002). An evolving theoretical framework for an epistemological belief system. In B. K. Hofer & P. R. Pintrich (Eds.), *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 103–118). Mahwah, NJ: Erlbaum.

Schommer, M., Crouse, A., & Rhodes, N. (1992). Epistemological beliefs and mathematical text comprehension: Believing it is simple does not make it so. *Journal of Educational Psychology*, 84, 435–443.

Schraw, G., & Olafson, L. J. (2002). Teachers' epistemological worldviews and educational practices. *Issues in Education*, 8, 99–148.

Schraw, G., & Sinatra, G. M. (2004). Epistemological development and its impact on cognition and academic domains. *Contemporary Educational Psychology*, 29, 95–102.

Schraw, G., Bendixen, L. D., & Dunkle, M. E. (2002). Development and validation of the Epistemic Belief Inventory (EBI). In B. K. Hofer & P. R. Pintrich (Eds.), *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 261–275). Mahwah, NJ: Erlbaum.

Shadish, W. R., Cook, T. D., & Campbell, D. T. (2002). *Experimental and quasi-experimental designs for generalized causal inference*. Boston, MA: Houghton Mifflin.

Slotta, J. D., & Chi, M. (2006). Helping children understand challenging topics in science through ontology training. *Cognition and Instruction*, 24, 261–289.

White, B. C. (2000). Pre-service teachers' epistemology viewed through perspectives on problematic classroom situations. *Journal of Education for Teaching*, 26, 279–305.

White, B., & Frederiksen, (2005). A theoretical framework and approach for fostering metacognitive development. *Educational Psychologist*, 40, 211–223.

Wilcox-Herzog, A. (2002). Is there a link between teachers' beliefs and behaviors? *Early Education and Development*, 13, 79–106.

Woolfolk-Hoy, A., & Burke-Spero, R. (2005). Changes in teacher efficacy during the early years of teaching: A comparison of four measures. *Teaching and Teacher Education*, 21, 457–471.

Woolfolk-Hoy, A., Davis, H., & Pape, S. J. (2006). Teacher knowledge and beliefs. In P. A. Alexander & P. H. Winne (Eds.), *Handbook of educational psychology* (2nd edition, pp. 715–737). Mahwah, NJ: Erlbaum.

Yang, F. (2005). Student views concerning evidence and the expert in reasoning a socio-scientific issue and personal epistemology. *Educational Studies*, 31, 65–84.

Chapter 3
The Evolution of Self-Authorship

Marcia Baxter Magolda

Abstract Global citizenship requires understanding complexity, negotiating multiple perspectives, intercultural sensitivity, lifelong learning, and the capacity for mutual, interdependent relations with others. These qualities are routinely endorsed as learning outcomes of higher education in the USA. Baxter Magolda's 20-year longitudinal study of young adult learning and development demonstrates that these learning outcomes require self-authorship or complex epistemological beliefs accompanied by complex understanding of self and relationships. The longitudinal narratives illustrate how epistemology develops over time, its relationship to learning in higher education and adult life, and the conditions participants encountered that promoted complex epistemology and learning simultaneously. This chapter will present Baxter Magolda's theory of the evolution of self-authorship, integrating epistemological growth with identity and relationship growth, based on the longitudinal data. The Learning Partnerships Model, also derived from the longitudinal data, will be used to illustrate how educators can create the conditions that promote learning, complex epistemology, and self-authorship.

3.1 Introduction

What form of personal epistemology is required for managing the complexity of adult life? An Association of American Colleges and Universities report advances that "intentional learning" is necessary:

> In a turbulent and complex world, every college student will need to be purposeful and self-directed in multiple ways. Purpose implies clear goals, an understanding of process, and appropriate action. Further, purpose implies intention in one's actions. … Intentional learners are integrative thinkers who can see connections in seemingly disparate information and draw on a wide range of knowledge to make decisions. They adapt the skills learned in one situation to problems encountered in another: in a classroom, the workplace, their communities, or their personal lives. As a result, intentional learners succeed even when instability is the only constant. (AAC&U, 2002, pp. 21–22)

Miami University of Ohio, Oxford, USA

M. S. Khine (ed.), *Knowing, Knowledge and Beliefs: Epistemological Studies across Diverse Cultures.*

Societal expectations in the Netherlands also call for integrative thinking and application across contexts according to Erik van Rossum and Rebecca Hamer, who note that, “Graduates are expected to be able to gather, process and create knowledge independently, and large value is placed on solving realistic problems and logical thinking” (2004, p. 129). UK scholar Ronald Barnett offers a similar argument for what he calls a supercomplex world:

> It is a world where nothing can be taken for granted, where no frame of understanding or of action can be entertained with any security. It is a world in which we are conceptually challenged, and continually so. A complex world is one in which we are assailed by more facts, data, evidence, tasks and arguments than we can easily handle within the frameworks in which we have our being. By contrast, a supercomplex world is one in which the very frameworks by which we orient ourselves to the world are themselves contested. Supercomplexity denotes a fragile world but it is a fragility brought on not merely by social and technological change; it is a fragility in the way that we understand the world, in the way in which we understand ourselves and in the ways in which we feel secure about acting in the world. (2000b, p. 3)

These scholars, among others, advocate organizing higher education to promote the personal epistemology necessary to function effectively in this unstable, complex world. Doing so requires transformational learning that focuses on “how we learn to negotiate and act on our own purposes, values, feelings, and meanings rather than those we have uncritically assimilated from others” (Mezirow, 2000, p. 8).

Major studies of the development of personal epistemology articulate the evolution of how people negotiate meaning from simpler to more complex ways of knowing (see Hofer & Pintrich, 2002, for an overview). William Perry’s (1970) groundbreaking research offered one of the first trajectories of US male college students’ beliefs about knowledge. Patricia King and Karen Kitchener’s (1994) 20-year longitudinal study extended Perry’s work in its focus on views of knowledge and justification of beliefs. Belenky et al.’s (1986) study of women offered additional insight into the role of self and identity in epistemological assumptions. Robert Kegan (1994) explicitly articulated three major intertwined dimensions of meaning making in adulthood: epistemological, intrapersonal (i.e., identity), and interpersonal (i.e., relationships). The ability to generate one’s own internal belief system (epistemological complexity) also requires an internal sense of self and values (intrapersonal complexity) and the capacity to consider but not be overwhelmed by the views of others (interpersonal complexity). These three dimensions are similar to Barnett’s (2000a) constructs of epistemology (knowing), ontology (self-identity), and praxis (action). Collectively, this research demonstrates that complex epistemological, intrapersonal, and interpersonal development, or what Kegan (1994) calls self-authorship, is a necessary foundation for contemporary higher education learning outcomes such as critical thinking, understanding complexity, negotiating multiple perspectives, intercultural maturity, lifelong learning, and the capacity for interdependence with others.

In this chapter I introduce one theory of the evolution of self-authorship based on a 20-year longitudinal study. I also introduce the Learning Partnerships Model, a framework for educational practice derived from participants’ reports of dynamics that promoted self-authorship. Examples of the model's use in various contexts, as well as its relation to other models, offer readers insights into structuring higher education to promote the self-authorship needed for adult life.

3.2 Longitudinal Study Methodology and Method

My longitudinal study of young adult development and learning (Baxter Magolda, 1992, 2001), in which I have followed participants from age 18 to 38, provides empirical support for the argument that today's learning goals require complexity in how we know, how we see ourselves, and how we construct our relations with others. This constructivist study, originally designed to explore gender differences based on the work of Perry (1970) and Belenky et al. (1986), began with 101 traditional age students (51 women and 50 men) when they began college in 1986 at a state institution in the USA with a liberal arts focus. Admission is competitive and 70% of entering class of which the participants were a part ranked in the top 20% of their high school class. Their majors included all six divisions within the institution (i.e., arts and sciences, education, fine arts, interdisciplinary studies, business, engineering, and applied sciences), and cocurricular involvement in college was high.

Of the 70 participants continuing in the post-college phase of the study, 21 pursued additional academic preparation after college graduation, including law school, seminary, medical school, and various graduate degrees. Their occupations included business, education, social service, ministry, and government work. Attrition over the last 15 years resulted in 36 participants by year 20. Of these 36, 31 were married, 2 were divorced, and 22 had children. Seventeen had been or were pursuing advanced education: 12 had received master's degrees in education, psychology, social work, business administration, and economics. One had completed seminary, two received law degrees, and one completed medical school. One was taking undergraduate teacher education courses; another completed a doctorate. The most prevalent occupations of these 36 participants were business (16) and education (9). Areas within business included sales in varied industries, financial work, public services, real estate, and marketing. Educators were secondary school teachers. The remaining participants were in social work, law, homemaking, and Christian ministry.

The annual interview began with a summary of the focus of the project, which was to continue to explore how participants learn and come to know. The participant was then asked to think about important learning experiences that took place since the previous interview. The participant volunteered those experiences, described them, and described their impact on her or his thinking. I asked questions to pursue why these experiences were important, factors that influenced the experiences, and how the learner was affected. The interview became increasingly unstructured (Fontana & Frey, 2000) as the study progressed and addressed what life had been like for participants since we talked last. These conversations included discussion of the dimensions of life they felt were most relevant, the demands of adult life they were experiencing, how they made meaning of these dimensions and demands, their sense of themselves, and how they decided what to believe. Inherent in these dimensions was their sense of themselves in relation to others and their involvement in significant relationships. Interviews were conducted in person during college and by telephone after college; they ranged from 60 to 90 minutes.

My constructivist approach to this project and the partnership developed over the course of the study with participants both mediate data interpretation. My constructivist approach led to using grounded theory methodology (Charmaz, 2003; 2006) to analyze interview responses. Each year transcriptions of the taped interviews were reviewed and divided into units. The units were then sorted into categories to allow themes and patterns to emerge from the data. Rereading data for each participant across years resulted in successively evolving interpretations and further development of patterns. Credibility of the themes and patterns is enhanced through prolonged engagement to build trust and understanding, and member checking to assure accuracy of interpretations. Two research partners joined me to reread and analyze the postcollege data. Each of us prepared summaries of themes individually followed by meetings in which we discussed and synthesized our perceptions. This use of multiple analysts helped mediate our subjectivities and increase the adequacy of our interpretations. (see Baxter Magolda, 1992, 2001 for more in-depth methodological details).

3.3 The Evolution of Self-authorship

The majority of my longitudinal participants entered college dependent on external authorities for what to believe, how to identify themselves, and how to relate to others. Over the course of their college experience, multiple perspectives among external authorities and the societal message that young adults should take responsibility for themselves led participants to rely less on external sources and consider relying on their own internal voices. It was not until after college, however, that most were able to bring their voices to the foreground to construct their own beliefs, identities, and interdependent relations with others. Table 3.1 offers an overview of this journey. The narratives that follow trace this journey from defining oneself externally to defining oneself internally.

3.3.1 Following External Formulas

Over half of the longitudinal participants entered college believing that knowledge is certain. They viewed their role as learners as acquiring information from authorities. Eileen portrayed this perspective:

Table 3.1 Developmental journey toward self-authorship (Adapted from *Learning partnerships: Theory and models of practice to educate for self-authorship*, edited by Marcia B. Baxter Magolda and Patricia M. King (Sterling, VA: Stylus Publishing, LLC) with permission of the publisher. Copyright © 2004, Stylus Publishing, LLC)

Dimension	External Formulas	Crossroads	Self-authorship
Epistemological	View knowledge as certain or partially certain, yielding reliance on authority as source of knowledge; lack of internal basis for evaluating knowledge claims results in externally defined beliefs	Evolving awareness & acceptance of uncertainty & multiple perspectives; shift from accepting authority's knowledge claims to personal processes for adopting knowledge claims; recognize need to take responsibility for choosing beliefs	View knowledge as contextual; develop an internal belief system via constructing, evaluating, & interpreting judgments in light of available evidence and frames of reference
Intrapersonal	Lack of awareness of own values and social identity, lack of coordination of components of identity, and need for others' approval combine to yield an externally defined identity that is susceptible to changing external pressures	Evolving awareness of own values and sense of identity distinct from external others' perceptions; tension between emerging internal values and external pressures prompts self-exploration; recognize need to take responsibility for crafting own identity	Choose own values & identity in crafting an internally generated sense of self that regulates interpretation of experience and choices
Interpersonal	Dependent relations with similar others are source of identity and needed affirmation; frame participation in relationships as doing what will gain others' approval	Evolving awareness of limitations of dependent relationships; recognize need to bring own identity into constructing independent relationships; struggle to reconstruct or extract self from dependent relationships	Capacity to engage in authentic, interdependent relationships with diverse others in which self is not overshadowed by need for others' approval, mutually negotiating relational needs; genuinely taking others' perspectives into account without being consumed by them

> I have to see what I'm learning, and I have to know why. I have a good memory, and it's very easy for me to memorize facts. The advantage is that it is kind of cut and dried. The information is there – all you have to do is soak it into your brain. (Baxter Magolda, 1992, p. 77)

Although there were contexts in which this absolute way of knowing was affirmed, there were others in which learning required something more. Encountering teachers who advocated multiple interpretations led students to acknowledge that in some areas knowledge is uncertain, at least temporarily. However, they continued to rely on authority to provide the rules for understanding this new uncertainty. Megan articulated this way of knowing:

> You have to know the rules to apply them. If you've applied them correctly and you know them, you're going to get a good grade. I mean, it's not just like memorize this and write it down. You have to know how to be able to use it, which I think just may be more effective than sitting down at a lecture, get notes, memorize them, and spit them back without really knowing. I couldn't tell you half of what I learned now because I memorized it for the exam. If you have to apply it, I feel I'm learning it more. (Baxter Magolda, 1992, p. 111)

Both ways of knowing, knowledge as certain or knowledge as partially certain, share a common characteristic – reliance on external authority as the source of knowledge. Participants using these ways of knowing lacked an internal basis for evaluating or making knowledge claims and thus their beliefs were externally defined. Although the belief that knowledge is certain disappeared by the middle of college, the belief that knowledge is partially certain prevailed throughout college for most participants.

Knowledge about one's identity also stemmed from external sources. Many students expressed their sense of identity through their description of their academic major. Carmen explained clearly how she relied on external sources for this decision:

> I did not really decide. My mother suggested majoring in zoology, so I did. An alternative was majoring in psychology. Psychology was interesting, but I really didn't know what I wanted to do. Premed in zoology is more productive and more challenging. If I become a doctor, I could become very proud of who I am. I would get personal satisfaction out of knowing that I worked hard and deserved to be where I am. (Baxter Magolda, 1992, p. 89)

Carmen's uncritical acceptance of her mother's suggestion reveals a lack of awareness of her own values and social identity. Her anticipation of being proud of who she would be as a doctor and deserving of this accomplishment hinges on social approval rather than any internal value system.

Students who recognized partial uncertainty reported a more complex process of decision making yet still relied heavily on external sources. Ned shared this advice on making career decisions:

> The best way to decide is to talk to a lot of people. It's like smart shoppers – get as much info as you can. Get involved in what you are thinking about doing. Take a class – there's no substitute for not knowing. After that, talk to a professional, an adviser, your father, your mother – somebody you trust. There're probably millions of places you could go to help make your career decisions, but mostly I consider professional advisers that know you well enough. I mean, they really have to know you. That's why a parent would be good. Even a professional. If they know you well, they have enough background that they can make a decision that you don't know about yet. You get ten worthy opinions. And after that, it's your own decision. (Baxter Magolda, 1992, p. 126)

Ned conveys that others who know you well enough can make decisions that you cannot make. Although he closes with the notion of making his own decision, he gives no indication of his values or identity or the ability to coordinate components of his identity into a career decision. Trusted others clearly know best.

The lack of internal beliefs, values and identity left participants susceptible to changing external pressures. They defined their identities through dependent relationships with similar others to acquire affirmation. Alexis expressed this perspective:

> I think that the attitude of your friends and your peers, people that you're with all the time, they really affect how hard you work. It just seems like the people that you're surrounded by, you tend to fall into the same rut they do. I find that if so-and-so's working harder, then I will. If they aren't going to study, I don't either. (Baxter Magolda, 1992, p. 307)

Alexis' behavior was completely tied to what others around her were doing. Participants also relied heavily on peers to process their experiences. Hugh offered:

> I'm living with seven other guys I'm pretty close to. We're good friends. And that whole atmosphere is pretty nice because of the support – being able to go and talk to anyone about anything you may want to talk about. Especially being a guy, I think it's good to just talk to someone about something. (Baxter Magolda, 1992, p. 314)

The common thread throughout these examples is the lack of an internal frame of reference yielding a reliance on external others for knowledge claims, one's sense of self, and how to relate to others. Most participants carried these external formulas into post college employment or graduate school where they promptly were challenged. Amy shared her struggle in graduate classes where she was asked to articulate her own opinion:

> That's one of my problems I have with writing things, you know, writing papers is actually showing my own ideas. I'm kind of scared of being completely off, and so I think I play the line very straight and I don't really take a lot of chances. And that's one thing I think I worked on in papers, trying to give my own opinion and not feeling that that was going to be completely off. That's one thing that – just in other things, not just in writing papers, but, you know, giving my own opinion or something, I'm always worried that what I say is not right. So I think – I know I'm always scared kind of about my creativity I guess, about how when something's in front of me and I have complete rein to do whatever I want, whether it's in a paper or doing a project or doing something, that kind of scares me because I feel like I can do better when I have specific guidelines. You know, 'You do this. You answer certain questions,' rather than – I don't know – 'Here, you have a paper and you can write it on anything you want.' And then I'm just like, 'Ooh.' I'd rather have a specific question to answer and work it out. (Baxter Magolda, 2001, pp. 86–87)

Amy's stress stemmed from being asked to draw on her internal voice – something she had not developed. Being asked to think for themselves in graduate education and employment settings challenged participants to look inward to begin to develop their own beliefs, values, and identities. Extracting oneself from external formulas was, however, an arduous task.

3.3.2 Crossroads

Recognizing the limitations of dependence on external formulas was far easier than constructing one's own perspectives. Even when participants could articulate this struggle, they could not immediately change their perspectives. Lauren's story about bringing a boyfriend to meet her parents illustrates this difficulty:

> He came home with me to [my parents' house] and I was totally gung-ho. I'm like, 'This is it; I know it.' And then after they gave me their feedback, they liked him but they were just not sure. And after they said that, all of a sudden I didn't like him as much anymore. It was nothing that he did to me; it was not the way he acted. It was nothing. But it was because of what they

> said, all of a sudden I started changing my mind. Yes, that's exactly true. But then my sister, on the other hand, is the opposite and is like, 'Just go with how you feel.' And my friends, my close friends here are like, 'Just go with how you feel.' So now it's gotten better. I'm trying to really think of what I want and not what they want. So this relationship is continuing, which they're not upset about at all, but I will tell you they have told me, 'Come on, this really isn't going to work. It's too far.' And that does affect me. But I'm really trying to take the attitude where maybe I need to find out for myself. But I will admit always in the back of my mind what they think still lingers over my decisions. (Baxter Magolda, 2001, p. 99)

Lauren saw the limitation of her dependence on her parents' perspectives. She recognized the importance of finding out for herself whether this relationship is right for her. Yet she had a hard time maintaining her own perspective, even though she "knew" it was right at the beginning. Only through her sister's and friends' support was she able to continue to explore her own feelings. Lauren's reliance on her parents' affirmation shapes what she knows, who she is, and how she frames her relationships. She does not know how to extract herself from this dependent relationship or how to reconstruct it to include her voice. Her awareness of this dilemma marks the beginning of the crossroads.

Increasing tension between external expectations and their own internal thoughts and feelings led participants to take action to resolve the conflict. Cara described the process of moving from awareness to action:

> I reached a snapping point; I said to myself, 'I won't do this again. I am in a Ph.D. program, what I wanted my whole life; I am making myself ill because of this. I am ruining my own dream.' I decided not to do it anymore. I just reached a snapping point. I was running one day; I decided I didn't have to do it anymore. (Baxter Magolda, 2001, p. 117)

This snapping point reflects Cara's recognition of the need to take responsibility for crafting her own identity. She elaborated:

> I have had a good intuitive sense but have ignored it; like in bad relationships; my stomach would clench. Then I'll have a logical or rational voice saying you are overreacting. In the last 6 months I've tried to listen more; spend 20 minutes a day and do breathing exercises. I'm used to reading to help myself; read what someone else is saying rather than listening to myself. The more I'm listening to myself, I'm allaying fears. I'm paying more attention to me than to other people; I made some bad decisions as a result of listening to others. I changed my major to psychology to stay at home with a boyfriend. I'm sick of listening to others! Then I think, 'I'm not honest with my parents.' When am I going to stand up for myself and be who I am instead of trying to make people happy? Or share my reaction when people aggravate me? (Baxter Magolda, 2001, p. 118)

Here Cara describes the tension between her emerging internal values and external pressures and the self-exploration she undertook to resolve it. Her evolving awareness of her own values and sense of identity distinct from external others' perceptions eventually enabled her to extract herself from complete reliance on external influence. When participants moved their own internal voices to the foreground to coordinate their beliefs, values, identities, and relations with others, they were on they way out of the crossroads.

Justin described what it was like to put one's internal voice in the foreground:

> I think my self-confidence has increased. I think my self-esteem has increased. I think my ability to form clear perceptions of what I interpret as reality has changed. I feel like I'm

> able to think a little more clearly now for some reason. Just to formulate perceptions of things has increased. I guess I could say my insight has increased. I think I'm less influenced by what goes on around me. I'm able to form my own perception of what's happening instead of being so influenced by people. I think a year ago I was pretty influenced by different groups of people. And now at this point in time I feel like I'm more myself and I'm able to form clear perceptions that are unbiased in regard to these other groups of people. Maybe this is because I've gotten sort of a direction now, or can kind of see myself moving in a direction. I'm a little more goal oriented this year. Last year, I mean, I was lost. I didn't know what I wanted to do; I didn't know anything. Not that I know exactly now, but at least I have a little clearer perception of where I want to go. I have goals now, which really kind of feels good. And I'm feeling more self-confident like I'll be able to meet these goals. The future seems a little more bright. (Baxter Magolda, 2001, pp. 114–115)

Justin's ability to form perceptions of reality without undue influence from external others reveals his shift from uncritically accepting authority's knowledge claims to personal processes for adopting knowledge claims. Because he feels he can think more clearly he is willing to accept responsibility for choosing what to believe. His use of the phrase "interpret as reality" implies his awareness of the uncertainty of knowledge and the existence of multiple perspectives. He attributes his increased confidence and self-esteem to a clearer sense of direction that stems from his newly formed internal voice. He stands at the threshold of self-authoring his life.

Most of the longitudinal study participants spent the majority of their 20s negotiating the crossroads. Meeting employers' expectations for complex thinking and problem solving, establishing career priorities, negotiating relationships with parents and partners, and making choices amid multiple possibilities forced participants into the crossroads. Developing an internal belief system, identity, and approach to social relations to guide adult experiences was a long and complicated endeavor.

3.3.3 Self-authorship

Complexity in the epistemological, intrapersonal, and interpersonal dimensions enabled participants to become the authors of their own lives. Self-authorship reflects the ability to internally define one's beliefs, values, identity, and social relations. Evan described how epistemological changes, which he refers to as how his mind works, influenced his ability to self-author his life:

> I told you about this feeling that I had once I became 'aware.' That is the best word that I can use to describe the difference between how I view my intellectual level now, versus how I felt prior to 'noticing' my surroundings and my relationship with the world around me. It was like I woke up one day and things just clicked in my brain and things became clear to me for the first time. The most dramatic difference between before and after was my ability to think, and the subsequent confidence in my abilities and trust in my decisions. I have developed my own approach to solving problems, one that has proven to me to be a good one, and one that has proven to be a good teacher. When it becomes apparent to me that I have relied on this ability, I often try to remember what I did before I began to understand how *my mind* worked. (Baxter Magolda, 2001, pp. 121–122)

Evan's awareness of how his mind works emerged from his success in problem solving. His ability to develop his own approach reflects his ability to develop an internal belief system by constructing, evaluating, and interpreting judgments in light of available evidence. This internal approach increased his level of trust in his decisions. It also helped him in crafting his identity. He explained:

> As my personality and sense of self have really begun to develop and become more refined, my ability to direct my life accordingly has become increasingly confident. As I realize who I am, and what is important to me, it becomes easier for me to establish my priorities. Identifying and arranging my priorities has helped me to develop a 'road map' for reaching short and long-term goals. Don't get me wrong, I am not trying to predict the future and I by no means know exactly what I want, but I have developed a general idea and use my knowledge as a guide. (Baxter Magolda, 2001, p. 122)

Making decisions about who he is and what is important to him helped him establish a map for his life. He recognized the uncertainty of the future, yet was confident in his ability to arrange his priorities. His comments demonstrate the ability to choose his own values and identity in crafting an internally generated sense of self that regulates interpretation of experience and choices.

Evan's internal sense of self also mediated his ability to self-author his social relations. Describing this experience, he said:

> I find that I am constantly rebalancing my identity in relationship to others. With my parents' divorce two years ago, and the purchase of my home, I am becoming a central figure in the extended family and have left behind my 'youth' oriented identity. At work, my identity continues to grow almost as fast as my personal identity. Since I began with the current crew 2 1/2 years ago, I have been titled Asset Manager, Senior Asset Manager, Assistant Vice President, and now Vice President. My identity within the group has changed very much. I owe this to my abilities in being aware of how my mind works and dealing with my personal set of realities. (Baxter Magolda, 2001, pp. 122–123)

Among Evan's personal set of realities were his parent's divorce, his father's incarceration, and a company merger in which others initially intended to dispense with him. His ability to establish his priorities, use his internally derived approach to problem solving, and rebalance his identity in these circumstances helped him succeed in both his personal and professional life. Evan was able to mutually negotiate relational needs with his family and engage in interdependent relationships with family and coworkers. Because he was driven by his internal priorities and identity, he was open to but not controlled by others' expectations. This capacity for interdependence characterizes self-authorship in which participants brought their internal sense of self to their relationships.

Whereas Evan described developing self-authorship beginning with an awareness of how his mind worked, some participants articulated the process starting in the intrapersonal dimension. Dawn, at 33, described the analysis she was doing about her life and identity:

> There is so much processing going on, what I do on a daily basis, trying to fit all the pieces of the puzzle together. I think I'm definitely at a point where I am really defining a lot about my life. Not that it is discovering new things – I'm sure I am – but bringing everything that I've ever thought and believed into a much clearer focus for myself. I'm in very deep thought about evaluating what is important, what is not so important, what gives me comfort, emotionally, mentally, discovering these things. … The whole thought process of just taking stock of where you are in your life. It's like putting your life through a sieve,

> getting the big awkward chunks out of your life, getting the nice finely sifted residue – it is kind of sorting it all out. What is the essence of you and what isn't? (Baxter Magolda, 2004b, pp. 18–19)

Dawn described sorting internally what she believed in order to refine the essence of her identity. Her refining of her values and identity led to increased respect for herself, which in turn mediated her social relations with others. She explained:

> You take in information and see how it feels given your accumulation of life experiences to that point. If it feels right you keep it; if it doesn't, you let it go. As far as thinking how that relates to like deeper issues, um, I think a lot of it also has to relate to the self, how you view yourself. If you respect yourself, if you have confidence in your ability, that changes your whole perspective. If you respect yourself, it is pretty much a given that you will respect others. Treating others with compassion and understanding can only happen when you've achieved a certain level of that yourself. Just thinking about the energy of the world and how we treat each other and how – that is a big defining thing for me right now. Stepping into that realm of not judging people, treating them with compassion, acting in my life without judging and with compassion. (Baxter Magolda, 2004b, pp. 19–20)

Dawn's new perspective, derived from respecting herself, enables her to engage int authentic, mutual relationships with others. Because she no longer worries about others judging her, she is free to refrain from judging others. Her ability to respect herself heightens her ability to respect others and treat them with compassion. Dawn further articulated how her internal self affected her assumptions about knowing:

> It's starting to feel – more like wisdom than knowledge. To me knowledge is an awareness of when you know things. You know them as facts; they are there in front of you. When you possess the wisdom, you've lived those facts, that information so fully that it takes on a whole different aspect than just knowing. It is like you absorbed that information into your entire being. Not just that you know things. It is something deeper. Knowledge is brain – wisdom comes from a different place I feel like. Something deeper connecting with your brain so that you have something different to draw from. A point where knowing you are going to do something – the knowledge has a deeper level – internal, intuitive, centered in entire being, the essential part of you that just – makes the basic knowledge pale by comparison. (Baxter Magolda, 2007, p. 71)

The shift from knowledge to wisdom implies that wisdom is the integration of what one knows with one's core sense of self. Dawn's merging of her beliefs with her core identity establishes a powerful internal system from which she makes sense of all aspects of her life.

Self-authoring one's life is an ongoing process. Even after their internal belief systems, identities and mutual social relations were established, participants continued to refine them in the course of everyday adult life. Dawn was diagnosed with MS at the age of 33. She reported her initial approach to incorporating this information into her identity as well as a substantive shift in her thinking:

> For the first 3 years, I've had to be a warrior – that has been my process with the MS thing. Strong, bold, brave, conquer to keep myself going forward. Somewhere in all of that I realized that I could let go of warrior. I'm steady, moving forward, now I kind of feel like my MS is more of a friend that helps guide me, gives me information on how to best proceed on my path. A shift in 'okay, I have MS' and I'm going to work with it, it with me, we have a great partnership together. My life has gotten much easier. I know how hard to push myself, know when to say stop. (Baxter Magolda, 2007, p. 71)

Although she initially found the warrior approach successful, over time it made sense to shift away from it. The flexibility that is characteristic of self-authorship – the capacity to continually refine one's sense of self, beliefs, and social relations – is crucial for the complexity of adult life.

3.3.4 Learning Partnerships: Supporting the Evolution of Self-authorship

Global citizenship requires understanding complexity, negotiating multiple perspectives, intercultural sensitivity, lifelong learning, and the capacity for mutual, interdependent relations with others. As such, global citizenship requires self-authorship. Research suggests that many US college students and adults do not typically reach self-authorship until later in life (Baxter Magolda, 2001; Kegan, 1994). Similarly, research with Dutch freshmen in tertiary education suggests that they, too, rely heavily on teachers as authorities (van Rossum et al. 2003; van Rossum & Schenk, 1984). However, Kegan (1994) describes development toward greater complexity as a response to demands from the environment. The longitudinal participants developed more complex ways of knowing when the context demanded them (Baxter Magolda, 2001). The longitudinal participants' stories about dynamics that facilitated their journey toward self-authorship illustrate how educators can create the conditions to promote self-authorship during the college years.

3.4 The Learning Partnerships Model (LPM)

Participants identified conditions that promoted their development in a variety of contexts including college, graduate and professional school, employment, volunteer work, and personal life. The Learning Partnerships Model (Baxter Magolda, 2004a), derived from these data, offers one approach to promoting self-authorship. The LPM combines support and challenge across epistemological, intrapersonal, and interpersonal dimensions to assist learners in constructing increasingly complex ways of viewing knowledge, themselves, and social relations (see Fig. 3.1). Greater support is required when learners are in the external phase of the journey because the demand for self-authorship is too far beyond their current ways of seeing knowledge, themselves, and social relations. Challenge can be increased as learners move through the crossroads and into self-authorship. The support/challenge balance is adjusted as necessary to simultaneously welcome the learners' current perspectives and invite them to consider more complex perspectives (Kegan, 1994).

Validating learners' capacity to know supports growth in the epistemological dimension. When employers or teachers invited participants to share their perspectives, showed respect for their ability to form a reasonable perspective, and

Fig. 3.1 Learning partnerships model

encouraged them to participate in decisions about what to think and do, learners gained confidence in their ability to participate in knowledge construction. *Portraying knowledge as complex and socially constructed* challenged participants who initially thought knowledge existed in external sources to join their employers and teachers in this social construction process. Encouragement that they could become valuable contributors in conjunction with the new awareness that knowledge is socially constructed helped participants work toward developing their own internal belief systems. To do so, however, requires progress on the intrapersonal dimension.

Situating learning in learners' experience supports them in seeing themselves as capable of learning and knowledge construction. Using learners' existing knowledge as the foundation for learning and decision-making, whether in formal learning or employment, offers a familiar context for learning and encourages learners to reflect on their existing perspectives. This support is crucial to help learners take up the challenge that *self is central to knowledge construction*. As they become aware that knowledge is complex and socially constructed, they must also become aware that they bring their identity and values to the process of deciding what to believe. Integration of the support of situating learning in their experience and the challenge that self is central to knowing helped the longitudinal participants move toward internally developed values and identities. Developing an internal identity depended, in part, on similar progress on the interpersonal dimension.

Defining learning as mutually constructing meaning supports learners to participate in the learning process. Learners who initially see their role as acquiring knowledge from authority have no concept that they might contribute to the learning process. When educators or employers explicitly conveyed that learning or work was a mutual endeavor, longitudinal participants became aware of their possible contribution and worked to change their roles. *Sharing authority and expertise* challenged participants to reframe their relationships with educators and employers. When authority figures expected participants to conduct independent research, analyze information, and offer judgments, participants worked to learn how to do this effectively. These demands, accompanied by the support of constructing meaning together, enabled participants to move away from dependence on authority to mutual relationships with others.

As longitudinal participants described their experiences, these supports and challenges were intertwined across dimensions. Movement out of external formula into the crossroads and movement out of the crossroads into self-authorship involved movement on all three dimensions. All three supportive components of the LPM intertwined to help participants cope with the challenges. Similarly, all three challenges were interrelated. The ability to internally generate a belief system was integrally tied to the ability to generate an internal identity and mutual relations with others (Baxter Magolda, 2001).

3.5 The LPM in Action: A Four-semester Core Curriculum

Concerned about their students' disconnection with their role as citizens in contributing to earth sustainability, earth and environmental scientists at Virginia Polytechnic Institute and State University (USA) developed a four-semester core curriculum using the LPM (Bekken & Marie, 2007). Recognizing that engaging students in the complexity of earth sustainability required "fully self-authored participants who are capable of viewing and applying knowledge in context and who can interpret the perspectives of others in light of multiple lines of evidence from various disciplines"(p. 54), they established learning goals that integrated content, technical skills, and growth toward self-authorship. An interdisciplinary team of faculty joined forces to implement the four-course series that also enabled students to meet five out of seven of the University's core curriculum goals through the series.

The Earth Sustainability series demonstrates the interconnections among content learning goals and development toward self-authorship. The faculty used a spiraling curriculum that repeated a multidisciplinary approach with increasing intellectual sophistication each semester. Content, technical skill, and developmental goals established for each semester reflected an increasingly complex curriculum over the four-course series. The core emphasis of each of the four courses was addressing complexity; recognizing assumptions and arguments; making connections; and responsibility and empowerment (Bekken & Marie, 2007). Specific learning goals increased in complexity for each course, as shown in this example (Bekken, 2005):

- Earth Sustainability 1: Worldviews and Water: Outline basic ethical arguments, cultural traditions and social, political, and economic institutions that shape debate and decision-making regarding sustainability.
- Earth Sustainability 2: Energy and Shelter: Identify and explain ethical arguments and cultural traditions that shape debates and decisions regarding the sustainable use of nonrenewable resources.
- Earth Sustainability 3: Food: Identify and explain ethical arguments, cultural traditions as well as social, political, and economic institutions that shaped decisions and debate regarding sustainable agriculture.
- Earth Sustainability 4: Waste, Health, and Ethics: Identify and explain ethical arguments, cultural traditions and social, political, and economic institutions that shape decisions and debate regarding waste, pollution, and contamination of the environment, and how these decisions affect ecosystems, biodiversity, and human health.

The first course emphasized outlining arguments, the second moved to identifying and explaining arguments, the third added new dimensions to explain, and the fourth required application of these arguments to ecosystems, biodiversity, and human health. All content goals of the series were conceptualized in this progressively complex manner.

Similarly, developmental goals were conceptualized to correspond to the content goals. For example, one progression in the epistemological dimension focused on using assumptions and arguments. ES1 focused on distinguishing opinions from arguments supported by evidence. ES2 shifted to uncovering hidden assumptions and biases and recognizing arguments. ES3 encouraged students to challenge disciplinary bias, presumptions, and assumptions whereas ES4 emphasized framing arguments from multiple perspectives based on logical development from evidence (Bekken & Marie, 2007). This progression helped learners discover the uncertainty of knowledge, learn how particular arguments were constructed, and finally to learn how to construct their own arguments in a responsible way.

A corresponding intrapersonal goal of practicing self-reflection and self-evaluation demonstrates a similar continuum. In ES1 this took the form of recognizing personal positions, in ES2 evaluating the basis for these positions, in ES3 considering and possibly revising previous positions based on evidence, and in ES4 self-correction in dialogue based on new evidence (Bekken & Marie, 2007). Interpersonal goals followed the same continuum. For example, working in groups began with setting group norms, goals and tasks (ES1), shifted to practicing consensus-building techniques (ES2), then asked learners to complete a group project on time with guidance (ES3), and finally asked learners to complete a group project without guidance (ES4) (Bekken & Marie, 2007). Numerous developmental goals in each dimension were clearly articulated by the faculty for each course of the series.

In addition to modeling good pedagogy by building the content cumulatively, this approach used the six dynamics of the LPM. ES1's focus on addressing complexity portrayed knowledge as complex and socially constructed but framed complexity in a way that validated students as capable of knowing. Because the focus was on outlining arguments or recognizing personal positions, students were able to succeed in meeting class expectations. Recognizing personal positions invited students to begin to see themselves as central to what they believed. Assignments in ES1 asked students to envision the future they wanted, analyze consumption practices in their extended families, and chose the ethical viewpoint they most valued. These assignments situated learning in their experience, validated them as knowers, and invited them to bring their identities into learning. Faculty used students' ideas and reflections in class to convey that learning was a mutual effort. Decisions about classroom process were shared with students, modeling sharing authority. Class discussion engaged students in exploring the content with the faculty rather than telling them what they should know.

Once students mastered recognizing complexity, the shift to understanding the basis of arguments and positions portrayed knowledge as complex and socially constructed in slightly more complicated fashion. Digging further into the source of assumptions and positions further highlighted the centrality of self in deciding what to believe. While the first two courses focused on taking things apart to see how knowledge was constructed, the third course focused on helping learners put it back together through making connections. Students were increasingly invited, both in class and in assignments, to form their own perspectives and positions. The fourth course then encouraged taking responsibility for those positions. Sharing of authority progressively increased over the series as the faculty asked students to take over creating discussion prompts, quizzes, and class minutes.

Students in the first implementation of the Earth Sustainability course series began with epistemological assumptions that knowledge was certain and they relied heavily on external authorities and formulas. By the fourth course in the series, they exhibited "far more complex and incipiently self-authored ways of knowing" (Bekken & Marie 2007, p. 65). Faculty observed that students increased in sensitivity to ethical issues and biases, were better able to recognize assumptions and arguments, had more tolerance for ambiguity, and were more likely to integrate the content with their everyday lives. Based on the success of this project, the series is now being implemented on a larger scale. The Earth Sustainability faculty's use of the LPM illustrates that promoting students' development toward self-authorship is crucial to students' achievement of content learning outcomes. Thus development and learning are inextricably intertwined.

3.6 Use of the LPM at Multiple Levels of Institutional Practice

The LPM has been used to structure individual courses, undergraduate and graduate curricula, cocurricular experiences, and faculty and staff development. Anne Hornak and Anna Ortiz (2004) used the LPM to help students face the challenge of understanding their White privilege in a community college business course. As a result they advocate using the LPM in multicultural education efforts to help students see their role in perpetuating and changing culture. Recognizing that students' lack of self-authorship made completing a senior thesis difficult, the faculty of the School of Interdisciplinary Studies (SIS) at Miami University of Ohio (USA) intentionally constructed a 4-year writing curriculum using the LPM (Haynes, 2004). The SIS writing curriculum "helps students progress steadily through three phases, from engagement with expressive modes to an increasingly critical awareness of and proficiency in disciplinary forms to interdisciplinary scholarship" (Haynes, 2004, p. 65). Similar to the increasing complexity in the Earth Sustainability series, the SIS curriculum invited students to put themselves into their writing, engage in peer exchange, and develop their beliefs through writing. A graduate curriculum at the same university uses the LPM to help graduate students achieve the self-authorship required for professional educational practice (Rogers et al., 2004).

The LPM has been implemented in both academic and cocurricular contexts to promote learning to work effectively with others. The Casa de la Solidaridad, a semester of study in El Salvador, uses the LPM to support its goal of educating students for global citizenship. Learning partnerships among the students, among the students and Casa staff, and with the Salvadorians helps students make meaning of the complexity they experience in El Salvador for their own lives (Yonkers-Talz, 2004). Similarly, partnerships among peers, coworkers, and staff assist participants of the 10-week Urban Leadership Internship Program to refine their role as citizens (Egart & Healy, 2004). The LPM is a central foundation for the Community Standards Model, a process through which students in residential college settings learn to live and work together productively (Piper & Buckley, 2004). In each of these settings, students come to understand multiple perspectives through direct interaction, clarify their own values and beliefs, and learn to develop mutual relations with diverse others.

The LPM also holds promise for structuring faculty and staff development. Virginia Polytechnic Institute and State University grounded its faculty study group program in the LPM yielding a number of progressive faculty projects including the Earth Sustainability project summarized earlier (Wildman, 2004). Administrators at the University of Nevada, Las Vegas used the LPM to frame a reorganization of their student life division (the staff component that facilitates the cocurricular aspect of higher education in the USA) to better promote student learning (Mills & Strong, 2004). These large-scale uses suggest that the LPM holds promise for helping educators reconceptualize educational practice.

3.7 Implications for Higher Education Learning and Teaching Environments

The experiences of my longitudinal participants and students in the settings that used the LPM support Kegan's (1994) assertion that developmental growth occurs when the context demands it and sufficient support is available to meet that challenge. If development is a response to demand in the environment, higher education can be organized to intentionally promote personal epistemology. Similar to the examples recounted here using the LPM, the Hotelschool the Hague constructed a curriculum to do just this (van Rossum & Hamer, 2004). This three-stage curriculum moves students progressively from authority dependent to more complex learning conceptions by challenging students to think for themselves, solve real problems, and eventually take responsibility for assignments and assessment. The first stage uses interactive lectures that challenge students to think for themselves to move students away from learning via memorizing. Stage two attempts to engage students in applying insights to real problems. In this stage the teacher takes on a facilitator role and uses complex assignments and assessment focused on application. Because stage three focuses on students' personal understanding of reality, instructors engage students in partnerships to construct real life assignments and assessment processes. The teaching conceptions used in this curriculum model the dynamics of the LPM and emphasize the importance of environmental demand and support for complex epistemology.

On a cautionary note, if development occurs in response to environmental demand, it may differ widely across contexts. For example, Jane Pizzolato (2003) found that high-risk college students who lacked external formulas for succeeding in college tended to develop self-authorship prior to attending college even though they sometimes had difficulty maintaining it without adequate support. Certainly varied experiences in socialization could lead to young adults developing toward self-authorship at very different paces. The theory of self-authorship offered in this chapter represents one possibility among many of how personal epistemology evolves and how higher education might be more intentional in enabling it.

References

Association of American Colleges and Universities (AAC&U). (2002). *Greater expectations: A new vision of learning as a nation goes to college*. Washington DC: Author.

Barnett, R. (2000a). *Realizing the University in an age of supercomplexity*. Buckingham: The Society for Research into Higher Education and Open University Press.

Barnett, R. A. (2000b). Supercomplexity and the curriculum. *Studies in Higher Education*, *25*(3), 255–265.

Baxter Magolda, M. B. (1992). *Knowing and reasoning in college: Gender-related patterns in students' intellectual development*. San Francisco, CA: Jossey-Bass.

Baxter Magolda, M. B. (2001). *Making their own way: Narratives for transforming higher education to promote self-development*. Sterling, VA: Stylus.

Baxter Magolda, M. B. (2004a). Learning partnerships model: A framework for promoting self-authorship. In M. B. Baxter Magolda & P. M. King (Eds.), *Learning partnerships: Theory and models of practice to educate for self-authorship* (pp. 37–62). Sterling, VA: Stylus.

Baxter Magolda, M. B. (2004b). Self-authorship as the common goal of 21st century education. In M. B. Baxter Magolda & P. M. King (Eds.), *Learning partnerships: Theory and models of practice to educate for self-authorship* (pp. 1–35). Sterling, VA: Stylus.

Baxter Magolda, M. B. (2007). Self-authorship: The foundation for 21st century education. In P. S. Meszaros (Ed.), *Advancing student's intellectual growth through the lens of self-authorship. New directions for teaching and learning* (pp. 69–83). San Francisco, CA: Jossey-Bass.

Bekken, B. M. (2005, April). *Making self-authorship a goal of core curricula: The Earth Sustainability pilot project*. Paper presented at the American Educational Research Association national meeting, Toronto, Canada.

Bekken, B. M., & Marie, J. (2007). Making self-authorship a goal of core curricula: The earth sustainability pilot project. In P. S. Meszaros (Ed.), *Advancing students' intellectual growth through the lens of self-authorship. New directions for teaching and learning* (pp. 53–67) San Francisco, CA: Jossey-Bass.

Belenky, M., Clinchy, B. M., Goldberger, N., & Tarule, J. (1986). *Women's ways of knowing: The development of self, voice, and mind*. New York: Basic Books.

Charmaz, K. (2003). Qualitative interviewing and grounded theory analysis. In J. A. Holstein & J. F. Gubrium (Eds.), *Inside interviewing: New lenses, new concerns* (pp. 311–330). Thousand Oaks, CA: Sage.

Charmaz, K. C. (2006). *Constructing grounded theory: A practical guide through qualitative analysis*. Thousand Oaks, CA: Sage.

Egart, K., & Healy, M. (2004). An urban leadership internship program: Implementing learning partnerships "Unplugged" from campus structures. In M. B. Baxter Magolda & P. M. King (Eds.), *Learning partnerships: Theory and models of practice to educate for self-authorship* (pp. 125–149). Sterling, VA: Stylus.

Fontana, A., & Frey, J. H. (2000). The interview: From structured questions to negotiated text. In N. K. Denzin & Y. S. Lincoln (Eds.), *Handbook of qualitative research* (2nd edition, pp. 645–672). Thousand Oaks, CA: Sage.

Haynes, C. (2004). Promoting self-authorship through an interdisciplinary writing curriculum. In M. B. Baxter Magolda & P. M. King (Eds.), *Learning partnerships: Theory and models of practice to educate for self-authorship* (pp. 63–90). Sterling, VA: Stylus.

Hofer, B. K., & Pintrich, P. R. (2002). *Personal epistemology: The psychology of beliefs about knowledge and knowing*. Mahwah, NJ: L. Erlbaum Associates.

Hornak, A., & Ortiz, A. M. (2004). Creating a context to promote diversity education and self-authorship among community college students. In M. B. Baxter Magolda & P. M. King (Eds.), *Learning partnerships: Theory and models of practice to educate for self-authorship* (pp. 91–123). Sterling, VA: Stylus.

Kegan, R. (1994). *In over our heads: The mental demands of modern life.* Cambridge, Massachusetts: Harvard University Press.

King, P. M., & Kitchener, K. S. (1994). *Developing reflective judgment: Understanding and promoting intellectual growth and critical thinking in adolescents and adults*. San Francisco, CA: Jossey-Bass.

Mezirow, J. (Ed.). (2000). *Learning as transformation: Critical perspectives on a theory in progress*. San Francisco, CA: Jossey-Bass.

Mills, R., & Strong, K. L. (2004). Organizing for learning in a division of student affairs. In M. B. Baxter Magolda & P. M. King (Eds.), *Learning partnerships: Theory and models of practice to educator for self-authorship* (pp. 269–302). Sterling, VA: Stylus.

Perry, W. G. (1970). *Forms of intellectual and ethical development in the college years: A scheme*. Troy, MO: Holt (Rinehart, & Winston).

Piper, T. D., & Buckley, J. A. (2004). Community Standards Model: Developing learning partnerships in campus housing. In M. B. Baxter Magolda & P. M. King (Eds.), *Learning partnerships: Theory and models of practice to educate for self-authorship* (pp. 185–212). Sterling, VA: Stylus.

Pizzolato, J. E. (2003). Developing self-authorship: Exploring the experiences of high-risk college students. *Journal of College Student Development*, 44(6), 797–812.

Rogers, J. L., Magolda, P. M., Baxter Magolda, M. B., & Knight-Abowitz, K. (2004). A community of scholars: Enacting the learning partnerships model in graduate education. In M. B. Baxter Magolda & P. M. King (Eds.), *Learning partnerships: Theory and models of practice to educate for self-authorship* (pp. 213–244). Sterling, VA: Stylus.

van Rossum, E. J., & Hamer, R. (2004). Learning and teaching: A model of linked continua of conceptions. In C. Rust (Ed.), *Improving student learning: Theory, research and scholarship*

(pp. 121–133). Proceedings of the 2003 11th International Symposium. Oxford, UK: The Oxford Centre for Staff & Learning Development.
van Rossum, E. J., & Schenk, S. M. (1984). The relationship between learning conception, study strategy and learning outcome. *British Journal of Educational Psychology*, 54, 73–83.
van Rossum, E. J., Hamer, R., & Würffel, I. (2003). Students' learning conceptions: Relationships with teaching conceptions and developments. In H. O. S. Wils (Ed.), *Kennis ontwikkelen* (pp. 79–98). Utrecht: Utrecht University (IVLOS).
Wildman, T. M. (2004). The learning partnerships model: Framing faculty and institutional development. In M. B. Baxter Magolda & P. M. King (Eds.), *Learning partnerships: Theory and models of practice to educate for self-authorship* (pp. 245–268). Sterling, VA: Stylus.
Yonkers-Talz, K. (2004). A learning partnership: U S college students and the poor in El Salvador. In M. B. Baxter Magolda & P. M. King (Eds.), *Learning partnerships: Theory and models to educate for self-authorship* (pp. 151–184). Sterling, VA: Stylus.

Chapter 4
Assessing the Multidimensionality of Students' Epistemic Beliefs Across Diverse Cultures

Michelle M. Buehl

Abstract Measurement is a critical issue in the study of individuals' beliefs about knowledge. Given the prominence of the multidimensional conceptualization of epistemic beliefs, it is important to examine the multidimensional measures of beliefs more closely. An examination of literature reveals that although many studies have been conducted with the Schommer Epistemological Questionnaire or related measures, there are variations with regard to the number of identified factors and the nature of the beliefs those factors are meant to represent. Further, additional knowledge dimensions have been proposed and new measures of multidimensional beliefs have been developed. Although some variations are to be expected due to the measures used, age of the participants sampled, and the forms of analyses employed, the role of students' cultural background must also be considered. In this chapter, I discuss the psychometric properties of the existing measures as well as how the factors that have been identified vary depending on the characteristics of participants and the analyses conducted. Emergent patterns from the existing studies and implications for refining and developing measures in future research are discussed.

4.1 Introduction

What is knowledge? What does it mean to know? Does knowledge change? If so, how? Philosophers have debated such issues for centuries. More recently, educational researchers have taken an interest in such questions from a psychological perspective in an effort to understand the nature and role of individuals' beliefs about knowledge and knowing (i.e., epistemic beliefs) in the learning process. At first glance, understanding students' beliefs about knowledge and knowing may seem trivial or esoteric in the face of current issues and problems in education. However, evidence from this growing area of research suggests that such beliefs are significant.

George Mason University, Virginia, USA

M. S. Khine (ed.), *Knowing, Knowledge and Beliefs: Epistemological Studies across Diverse Cultures.*

To date, empirical findings indicate that individuals' beliefs about knowledge are related to other beliefs, behaviors, and academic outcomes (e.g., Ryan, 1984; Hofer, 2000; Sinatra & Kardash, 2004). For instance, beliefs about the certainty or simplicity of knowledge are related to the types of strategies students use when studying (e.g., Kardash & Scholes, 1996; Paulsen & Feldman, 1999) as well as their academic performance (e.g., Hofer, 2000; Schommer, 1993). Understanding how knowledge beliefs relate to other factors within the learning environment may help to account for students' successes and difficulties in the classroom and offer an avenue for improving education. That is, if specific beliefs are more advantageous for students' academic outcomes, educational experiences can be designed to foster such beliefs. However, this work cannot be done unless we know what we are studying. Issues related to the conceptualization and measurement of beliefs are critical.

Within the literature, a multidimensional view of epistemic beliefs has been forwarded and used to guide research. That is, individuals are believed to possess a system of beliefs about the different aspects or dimensions of knowledge (e.g., Hofer & Pintrich, 1997; Schommer, 1990). However, a variety of belief factors have been identified, some reflective of the proposed dimensions and others less so. Such variations are to be expected due to the sampled populations, as well as the specific measures and forms of analyses employed. Further, it is not readily apparent how the proposed multidimensional beliefs are manifested in various cultural contexts. The purpose of this chapter is to review existing studies examining the dimensionality of epistemic beliefs in an effort identify possible patterns in the emergent belief factors within and across cultures.

4.2 Dimensionality of Individuals' Beliefs about Knowledge

William G. Perry (1970) is credited with being one of the first to examine students' beliefs about knowledge empirically from a psychological perspective in his efforts to understand intellectual development of college students. Perry, and those who initially followed him (e.g., Baxter Magolda, 1992; Belenky et al., 1986; King & Kitchener, 1994; Kuhn, 1991), proposed a series of qualitatively different perspectives about knowledge individuals progressed through depending on their age and experiences. Although researchers may have queried participants about various aspects of knowledge (e.g., its origins or certainty), individuals' beliefs were characterized by only one perspective, belief category, or developmental level.

This approach is described as being *unidimensional* in that individuals are only charted along a single dimension pertaining to beliefs about knowledge (e.g., Duell & Schommer-Aikins, 2001). The categorizations do not acknowledge that individuals' beliefs about the various aspects of knowledge may be at different levels of sophistication. Instead, individuals' knowledge beliefs are considered to be relatively similar or *synchronous* such that it is possible to classify an individual as taking a particular stance toward knowledge (Schommer-Aikins, 2004). Further, individuals' beliefs were typically ascertained through extensive interviews or open-ended written responses.

Marlene Schommer-Aikins (previously Schommer) added to this literature by providing a new model for conceptualizing beliefs and developing a paper-and-pencil measure of beliefs. Specifically, she proposed a *multidimensional* and *asynchronous* model of beliefs in which that individuals posses a system of independent beliefs about different aspects of knowledge that may vary in their level of sophistication and development (Schommer, 1990). Schommer initially proposed five knowledge belief dimensions related to the structure, certainty, and source of knowledge, as well as the speed and control in the acquisition of knowledge.

4.3 Measures of Multidimensional Knowledge Beliefs

To assess these dimensions, Schommer (1990) developed the *Schommer Epistemological Questionnaire* (SEQ). This measure contained 63 items organized into 12 conceptually derived subsets. Schommer factor analyzed composite scores from the 12 subsets and identified belief factors reflective of her four of her five proposed dimensions. Specifically, although a factor related to beliefs about the source of knowledge did not emerge, Schommer identified belief factors related to the structure of knowledge (i.e., "Knowledge is simple rather than complex" (Schommer, 1990, p. 499)), the certainty of knowledge (i.e., "Knowledge is certain rather than tentative" (Schommer, 1990, p. 499), the speed of knowledge acquisition (i.e., "Learning is quick or not at all" (Schommer, 1990, p. 499), and the control an individuals has over the acquisition of knowledge (i.e., "The ability to learn is innate rather than acquired" (Schommer, 1990, p. 499)). Schommer labeled these factors to reflect what she considered a more naïve perspective and referred them to as simple knowledge, certain knowledge, quick learning, and innate ability (also sometimes referred to as fixed ability). The SEQ, or a modified version of the instrument (e.g., Kardash & Howell, 2000; Mori, 1999), has been used in multiple investigations.

Further, additional dimensions of epistemic beliefs have been proposed and new measures of multidimensional beliefs developed (e.g., Hofer, 2000; Jehng et al., 1993). Many of these measures have been based, at least in part, on the SEQ (e.g. Jehng et al., 1993; Schraw et al., 1995), For instance, Jehng et al. (1993) added items to the SEQ to represent an additional aspect of knowledge (i.e., beliefs about the regularity of the learning process) and eliminated items related to structure of knowledge (i.e., simple knowledge). Schraw et al. (1995) developed the *Epistemic Belief Inventory* (EBI) to assess the source of knowledge dimension that Schommer initially proposed and to further refine the assessment of beliefs. My colleagues and I (Buehl et al., 2002) used the SEQ as an initial framework for developing a measure to assess domain-specific beliefs about knowledge.

However, other measures reflect alternative conceptualizations of individuals' beliefs about knowledge (e.g., Bartholome et al., 2006; Elder, 2002; Hofer, 2000).

In particular, in their review, Hofer and Pintrich (1997) identified specific concerns with the extant belief literature, including the definition of epistemic beliefs as a construct and the lack of conceptual clarity regarding various belief dimensions. That is, Hofer and Pintrich (1997) claimed that two of Schommer-Aikins' factors (i.e., Innate Ability and Quick Learning) pertained more to beliefs about the nature of learning and intelligence than beliefs about knowledge. Hofer and Pintrich subsequently proposed that epistemic beliefs be limited to individuals' beliefs about knowledge and beliefs about knowing. They posited four belief dimensions (i.e., certainty of knowledge, simplicity of knowledge, source of knowledge, and justification for knowledge). Hofer (2000) developed a questionnaire to assess these dimensions. She found evidence of four belief factors related to certainty/simplicity of knowledge, personal justification for knowing, authority as a source of knowledge, and the attainability of the truth in two academic domains: science and psychology. Further the dimensions posited by Hofer and Pintrich (1997) have been used to guide the development of additional measures (Braten et al., 2005; Karabenick & Moosa, 2005).

Although there are some consistencies in the factors that emerge in studies that have used these and other measures, there are also some variations. These differences may be due in part to modifications made to the measure or the type of analyses employed. Additionally, investigations have been conducted with individuals of varying ages and from countries throughout the world.

Given that the emergence of a construct, as well as its relations to other relevant constructs, rests largely on the way that it is assessed, the measures and techniques used to assess individuals' multidimensional beliefs and characteristics of the sample need to be carefully considered. Thus, in this chapter, I review those studies that have explored the multidimensionality of students' beliefs. The specific goals of this chapter are to:

- Document trends and emergent patterns in the study of multidimensional knowledge beliefs with respect to the sampled participants, measures employed, analyses conducted, and reporting practices
- Identify the factors that have emerged using measures designed to assess students' multidimensional beliefs about knowledge
- Make recommendations for refining and developing multidimensional measures of epistemic beliefs

4.4 Search Parameters and Inclusion Criteria

This review focuses on studies investigating students' multidimensional beliefs about knowledge. Specifically, an exhaustive search of existing academic databases (i.e., PsychINFO and ERIC) was conducted using a variety of search terms (e.g., *epistem* belief**, *beliefs about knowledge*, and *knowledge belief**). Searches were also conducted using the names of authors known to publish on this topic and the reference lists of identified works were examined.

These procedures identified numerous works and criteria were developed to select those for additional review and analysis. Specifically, I chose to include published works written in English through 2006 that focused on students' multidimensional beliefs about knowledge and explicitly examined the underlying factor structure of these beliefs. That is, conference papers, dissertations, and other unpublished works were not included. Nor were studies focusing on nonstudent populations (e.g., teachers: Kang & Wallace, 2005; Marra, 2005; mothers: Burns & Bond, 2004). Works that focused solely on learning beliefs, identified only a single factor, or applied a factor structure identified in a previous investigation were also excluded from further consideration.

Further, efforts were made to include only investigations that represented a unique sample, analysis, and or belief structure. Specifically, some authors have published multiple publications using the same data set. When this was identified, a decision was made about which publication to include. Typically, the first published work fitting my criteria was the one selected. Exceptions were made if a later study provided a more detailed discussion of the analyses and findings or a larger sample. For instance, I included Cano (2005) instead of Cano and Cardelle-Elawar (2004) because the 2005 publication was based on 1,600 participants instead of 1,200. However, the description of the sample, analyses, identified factors, and reported reliability coefficients suggest that that the sample in the 2004 publication is a subsample of the sample in 2005. As another case in point, the sample characteristics and results in Schommer and Dunnell (1994) are similar to those reported in Schommer (1993), but the description of the analyses is more detailed in Schommer (1993). Thus, Schommer (1993) was included in the table and Schommer and Dunnell (1994) was not.

There was one exception to the unique sample criteria. Specifically, Schommer-Aikins and her colleagues published two articles based on a sample of 1,269 seventh- and eighth-grade students. The descriptions of the participants are identical. However, Schommer-Aikins et al. (2000) employed confirmatory factor analysis and identified three belief factors related to ability to learn, speed of learning, and stability of knowledge. Schommer-Aikins et al. (2005) used exploratory factor analysis with the same data and identified four factors related to quick/fixed learning, studying aimlessly, omniscient authority, and certain knowledge. I chose to include this duplicate because different analyses were used each time and different factors structures were identified. This serves as an example of how the type of analysis conducted can influence the belief factors that are identified.

4.5 Organization of Information

As a means to organize the information from the published works I identified, I created a table summarizing key information (Table 4.1). For each entry in the table, I recorded publication information (i.e., authors and year of publication) as well as information related to the sample, measure, analysis, and identified factors. This information was originally recorded chronologically by year to provide a

Table 4.1 Multidimensional epistemic beliefs factors

Author(s), Year	N Ed.Level	Country	Measure Details	Analysis	Factor Labels (No. of items/subsets[a], α)	Description[b]	Items[c]	Coefficients[d]
AGE GROUP Multidimensional Conceptualization of Beliefs Used to Frame Measure								
Measure								
POST-SECONDARY STUDENTS Schommer (1990) Conceptualization								
Schommer Epistemic Belief Questionnaire								
Schommer, 1990	266 Ungrd	USA	*Schommer Epistemological Questionnaire* (SEQ) • Designed to assess five belief dimensions: "structure, certainty, and source of knowledge, and the control and speed of knowledge acquisition" (p. 498) • 63 items, 12 subsets • 5-point scale	Exploratory Factor Analysis (EFA): • Principal factoring of 12 item subsets • Extraction – eigenvalues > 1 • Varimax and oblique rotation conducted, varimax reported • 55.2% of variance explained • Loadings > .50	Simple Knowledge (3 subsets) Certain Knowledge (1 subset) Innate Ability (3 subsets) Quick Learning (1 subset)	D D D D	S S S S	Y
Schommer et al., 1992	424 Ungrd & Grad	USA	SEQ (Schommer, 1990) • 63 items, 12 subsets • 5-point scale	EFA • Principal factoring of 12 item subsets • Extraction – eigenvalues > .96 (greater > 1 rule resulted in 3 factors) and previous work • Varimax rotation	*3-Factor Solution:* Innate Ability Simple Knowledge Certain Knowledge *4-Factor Solution from EFA:* Externally Controlled Learning	 D D D D	 S S S S	Y Y

				• 54.2% of variance explained • Loading criterion not indicated	Simple Knowledge	D	S	
					Quick Learning	D	S	
				Confirmatory Factor Analysis (CFA) • Applied 4-factor structure from Schommer (1990) and compared it to the 3-factor structure that emerged with eigenvalue greater than one criteria • Reported that the 4-factor Schommer (1990) model provided the best fit of the data • 4-factor model fit statistics – GFI = .94; AGFI = .90; SRMSR = .066; χ^2 (48) = 165.45	Certain Knowledge	D	S	
					4-Factor Solution from CFA: Factors not explicitly labeled but Experiment 2 uses labels from Schommer (1990)			N
Bendixen et al., 1994	125 Ungrd & Grad	USA	SEQ (Schommer, 1990) • 63 items • 5-point scale	EFA • Principal factor analysis of 63 items • Extraction – eigenvalues > 1 • Orthogonal rotation • 44% of variance explained • Loadings > .30	Certain Knowledge (12, .75)	R	X	N
					Quick Learning (9, .69)	R	X	
					Fixed Ability (6, .61)	R	X	
					Simple Knowledge (7, .65)	R	X	
Kardash & Scholes, 1996	96 Ungrd	USA	Shortened SEQ (Schommer, 1990) • "[T]hose items that dealt most closely with beliefs regarding the certainty and structure of knowledge and the speed of its acquisition" (p. 263) • 42 items, 11 subsets • 7-point scale	EFA • Principal axis factor analysis of 11 subsets • Extraction – forced a 4-factor solution • Varimax rotation • 34.9% of variance explained • Loadings > .35 with overlap < .25	Quick Learning (3 subsets)	R	X	Y
					Certain Knowledge (1 subset)	DS	X	
					Innate Ability (2 subsets)	R	X	
					Depend of Authority (1 subset)	DS	X	

(continued)

Table 4.1 (continued)

Author(s), Year	N Ed.Level	Country	Measure Details	Analysis	Factor Labels (No. of items/subsets[a], α)	Description[b]	Items[c]	Coefficients[d]
AGE GROUP								
Multidimensional Conceptualization of Beliefs Used to Frame Measure								
Measure								
Mori, 1999	187 Ungrd & Grad	USA	Shortened SEQ (Schommer, 1995) • Intended to assess 5 belief dimensions • 40 items • 6-point scale	EFA • Principal factor method of 40 items • Extraction – scree plot; eigenvalues > 1 • Promax and varimax rotation conducted, promax rotation used to interpret factors • 75% of variance explained • Loadings > .40	Quick Learning (7) Simple Knowledge (4) Dependence on Authority (5) Attainability of Truth (2) Innate Ability (2)	D D D D D	A A A A A	Y
Kardash & Howell, 2000	288 Ungrd	USA	SEQ (Schommer, 1990) • "[R]egarding the certainty and structure of knowledge and the speed of its acquisition" (p. 526) • 42 items, 11 subsets • 7-point scale	EFA • Principal axis factor analysis 11 subsets • Extraction – specified four factors based on Schommer (1990) • Varimax rotation • 31% of variance explained (after rotation) • Loadings > .35 with other loadings < .25	Nature of Learning (3 item subsets) Speed of Learning (3 item subsets) Certain Knowledge (1 item subset) Avoid Integration (2 item subsets)	D D D D	X X X X	Y

McDevitt et al., 1994	139 Ungrd	USA (48), Ireland (39), Australia (52)[a]	Modified SEQ (Schommer, 1990) • selected 3–4 items from 8 of SEQ 12 subsets • 31 items, 8 subsets • 5-point scale Learning Processes Measure • Based on measure by Schmeck, Ribich, and Ramanaiah (1976): true false items about synthesis-analysis, study methods, fact retention, and elaborative processing • 62 items • Binary scale Student motivation measure • 5 items • 5-point scale Open-ended listening questions used to create composites	EFA • Principal components analysis of 17 composite scores (i.e., 8 epistemology, 4 learning process, 1 motivation, 1 academic performance, and 3 listening composites) • Extraction – scree plot • Orthogonal rotation • 62.4% of variance explained • Loadings > .40	Avoidance of Inferential Processes (3 subscale composites)	D	S	Y
					Futility of Effort and Strategy (4 subscale composites)	D	S	
					Appreciation for Discrete Facts (3 subscale composites)	D	S	
					Personal Inquiry (2 subscale composites)	D	S	
					Behavioral Orientation to Listening (2 subscale composites)	D	S	
					Achievement Motivation (3 subscale composites)	D	S	
Chan & Elliott, 2000	352 Ungrd	Hong Kong	SEQ (Schommer, 1990) • 63 items • According to Chan and Elliott (2002) ◦ Translated into Chinese ◦ 5-point scale	EFA • Principal axis factor analysis of SEQ 12 subscales • Extraction – four factors based on previous work yielded uninterpretable structure; eigenvalues > 1 and scree plot indicated three factors • Both varimax and oblimim rotation conducted and reported • 46.5% of variance explained (three factors) • Loadings > .40	Fixed/Innate Ability (3 item subsets)	DS	X	Y
					Omniscient Authority (3 item subsets)	DS	X	
					Certain Knowledge (2 item subsets)	DS	X	

(continued)

Table 4.1 (continued)

AGE GROUP

Multidimensional Conceptualization of Beliefs Used to Frame Measure

Measure

Author(s), Year	N Ed.Level	Country	Measure Details	Analysis	Factor Labels (No. of items/subsets[a], α)	Description[b]	Items[c]	Coefficients[d]
Chan & Elliott, 2002	385 Ungrd	Hong Kong	Epistemological Belief Instrument • When Schommer's (1990) previous factor structure did not emerge in Chan and Elliott (2000), the authors developed a new measure based on Schommer's items and a review of the literature • 45 items • 5-point scale	EFA • Principal axis factor analysis of items • Extraction – method not reported • Oblimin rotation • % of variance not reported • Loadings > 30 CFA • LISREL • Same sample as EFA • 4-factor model with 30 items assigned to factors • 4-factor model fit statistics – GFI = .93; AGFI = .90; RMSEA = .058	Fixed/Innate Ability (8, .69)	D	A	Y
					Authority/Expert Knowledge (7, .60)	D	A	
					Certainty Knowledge (5, .60)	D	A	
					Learning/Effort Process (12, .66)	D	A	
Clarebout et al., 2001	*Study I:* 189 Ungrd	Belgium & the Netherlands	SEQ • Translated into Dutch in collaboration with Schommer • # items not reported • Scale not reported	EFA I • Exploratory factor analysis of subsets • Extraction – eigenvalues > 1 • Orthogonal varimax rotation • Loadings ≥ .50 • *Study I:* 54.48% of variance explained	*Study I*			Y
					For Most, Intelligence is Factual Knowledge (8, .68)	L	A	
					Scientists Know the Truth (2, .71)	L	A	
	Study II: 414 Ungrd	Belgium						

				• *Study II:* 50.31% of variance explained • Schommer's factor structure was not replicated EFA II • Principal components analysis of items to identify components and drop items • Extraction – eigenvalues > 1; scree plot • Loadings ≥ .40 • Remaining items iteratively submitted to factor analysis with varimax rotation • *Study I:* 14.69% of variance explained • *Study II:* 20.83% of variance explained	*Study II:* Scientists Know the Truth (2, 59) Meaning is Contextually Constructed (2, .53) Effort Pays (2, .70)	 L L L	 A A A	Y
Braten & Stromso, 2005	286 Ungrd	Norway	SEQ (Schommer, 1990) • Translated into Norwegian • 63 items • 5-point scale	Inter-item correlations used to drop items EFA • Principal components analysis of 48 items • Extraction – relative size of eigenvalues (i.e., 4 eigenvalues > 2);scree plot • Oblique rotation • First PCA: Loadings > .35 (items < .35 dropped) • Second PCA: Loadings > .40 and overlap < .30 • 33% of variance explained	Speed of Knowledge Acquisition (9, .70) Certainty of Knowledge (5, .62) Knowledge Construction and Modification (7, .62) (all reverse coded) Control of Knowledge Acquisition (3, .50)	D D D R	A A A A	Y

(continued)

Table 4.1 (continued)

Author(s), Year	N Ed.Level	Country	Measure Details	Analysis	Factor Labels (No. of items/subsets[a], α)	Description[b]	Items[c]	Coefficients[d]
AGE GROUP								
Multidimensional Conceptualization of Beliefs Used to Frame Measure								
Measure								
Jehng's Epistemological Questionnaire								
Jehng et al., 1993	398 Ungrd & Grad	USA	*Jehng's Epistemological Questionnaire* (JEQ) • Selected items from SEQ and Spiro's measure (1989) – "Schommer's framework [was] adopted for this study by replacing the Simple Knowledge dimension with 'Orderly Process'" (p. 28) • 51 items • 7-point scale	Inter-item correlations used to drop items CFA • LISREL • 5-factor model for 34 items • 5-factor model fit statistics – GFI = .93; χ^2 (517) = 571.44	Certainty of Knowledge Omniscient Authority Orderly Processes Innate Ability Quick Learning	D D D D D	S S S S S	N
Cole et al., 2000	101 Ungrd	USA	*Beliefs about Learning Questionnaire (BLQ)* • Developed from Jehng et al. (1993) • 60 items • 7-point scale	CFA • Subscales grouped into two dimensions • 2-factor model fit statistics ◦ Pre – GFI = .89; AGFI = .68; NFI = .77; χ^2 df ratio = 6.2:1 ◦ Post – GFI=.94; AGFI = .81; NFI = .89; χ^2 df ratio = 3.5:1	Nature of Learning Nature of Knowledge	DS DS	X X	N

Youn, 2000	496 Ungrd & Grad
	
	487 Ungrd & Grad
		USA
		South Korea
			Epistemological belief scale
			• Based on JEQ (Jehng et al., 1993) and 13 new items
			• Translation and backtranslation for Korean version
			• 74 items
			• 6-point scale
				13 new items dropped due to lack of emergent factors
				Inter-item correlations used to drop items from 61 remaining JEQ items
				CFA
				• SAS Pro Calis
				• Generalized Least Squared Method
				• Analysis conducting separately for each sample
				• Applied Jehng's et al. 5-factor structure
				• Multi-collinearity and multivariate kurtosis in both samples
				EFA
				• Principals axis factoring of items
				• Extraction – scree plot
				• *US sample:*
				  ◦ 49.9 % of variance explained
				  ◦ Loadings > 30
				• *Korean sample:*
				  ◦ 54.8 % of variance explained
				  ◦ Loadings > .35
				CFA
				• Compared the fit of the 2-factor and 5-factor models for each sample
				• Compared orthogonal and oblique solutions
				• Oblique solution provided better fit for both samples
					US sample
					Knowledge (16, .81)
					Learning (13, .74)
					Korean sample
					Knowledge (22, .78)
					Learning (12, .82)
					"Even though [this] factor included items from a knowledgable factor, omiscient authority, it was labeled *Learning* (italics in original) not only because the majority of the items were from the learning factors, but also because the Korean student-teacher interaction is personal in nature" (p. 95)
						
						DS
						DS
						
						DS
						DS
							
							X
							X
							
							X
							X
								N
								
								N

(continued)

Table 4.1 (continued)

Author(s), Year	N Ed.Level	Country	Measure Details	Analysis	Factor Labels (No. of items/subsets[a], α)	Description[b]	Items[c]	Coefficients[d]
AGE GROUP								
Multidimensional Conceptualization of Beliefs Used to Frame Measure								
Measure								
				• Accepted 2-factor oblique model due to concern about multicollinearity • 2-factor model fit statistics ◦ *US Sample* – CVI = 1.64; RMR = .14; χ^2 (376) = 694.70; χ^2/df = 1.85 ◦ *Korean Sample* – CVI = 1.12; RMR = .17; χ^2 (208) = 457.37; χ^2/df = 2.20				
Epistemic Belief Inventory								
Schraw et al., 1995	*Study I*: 212 Ungrd *Study II*: 124 Ungrd & Grad	USA	*Epistemic Belief Inventory* (EBI) • Designed to assess the 5 dimensions described by Schommer (1990) • 32 items • 5-pont scale	EFA • Principal factor analysis of 32 items • Extraction – eigenvalues > 1 • Oblique and varimax rotations conducted, varimax reported • Loadings > .30 with no cr oss loadings > .39 • *Study I:* 64% of va riance explained	Fixed Ability (*Study I:* 5, .87; *Study II:* 4, .84)	L	A	Y
					Certain Knowledge (*Study I:* 3, .76; *Study II:* 4, .76)	L	A	
					Omniscient Authority (*Study I:* 3, .76; *Study II:* 3, .71)	L	A	

				• *Study II:* 60% of variance explained	Simple Knowledge (*Study I:* 2, .67; *Study II:* 2, .63)	L	A	
					Quick Learning (*Study I:* 3, .74; *Study II:* 3, .73)	L	A	
Bendixen et al., 1998	154 Ungrd	USA	EBI (Schraw et al., 1995) • 32 items • 5-pont scale	EFA • Principal factor analysis of items	Certain Knowledge (4, .76)	L	S	N
				• Extraction – eigenvalues > 1	Innate Ability (4, .87)	L	S	
				• Varimax and oblique rotations conducted, varimax reported	Quick Learning (2, .74)	L	S	
				• 54% of variance explained	Simple Knowledge (3, .67)	L	S	
				• Loadings > .30 and no cross loadings > .30	Omniscient Authority (2, .76)	L	S	
Schraw et al., 2002	124 Ungrd & Grad	USA	SEQ (Schommer, 1990) • 61 items • 6-point scale EBI (Bendixen et al., 1998) • 28 items • 5-point scale	EFA • Principal factor analysis of items (conducted separately for each measure)	*SEQ*			Y
					Innate Ability (2, .74)	R	A	
				• Extraction – eigenvalues > 1	Certain Knowledge 1 (2, .74)	D	A	
				• Oblique and varimax rotations conducted, varimax reported	Incremental Learning (2, .64)	L	A	
				• Loadings > .30	Certain Knowledge 2 (2, .53)	D	A	
				• *SEQ* ◦ 19 eigenvalues > 1, only examined first five	Integrative Thinking (3, .61)	L	A	
				◦ 35% of variance explained by five factors	*EBI*			Y
					Omniscient Authority (3, .68)	R	A	
				• *EBI* ◦ Five eigenvalues > 1	Certain Knowledge (3, .62)	R	A	
				◦ 60% of variance explained by five factors	Quick Learning (3, .58)	R	A	
					Simple Knowledge (3, .62)	R	A	
					Innate Ability (3, .62)	R	A	

(continued)

Table 4.1 (continued)

Author(s), Year	N Ed.Level	Country	Measure Details	Analysis	Factor Labels (No. of items/subsets[a], α)	Description[b]	Items[c]	Coefficients[d]
			AGE GROUP Multidimensional Conceptualization of Beliefs Used to Frame Measure					
Measure								
Nussbaum & Bendixen, 2003	238 Ungrd	USA	EBI (Schraw et al., 2002) • 32 items • 5-point scale	EFA • Principal components analysis (assumed to be conducted on items based on construction of EBI) • Extraction – forced a 5-factor solution; only 3 were interpretable • Promax rotation • 40% variance explained • Loadings > .30 • Items dropped if cross-loading or reduction of internal consistency	Simple Knowledge (7, .69)	D	A	Y
					Certain Knowledge (10, .69)	D	A	
					Innate Ability (9, .77)	L	A	
Domain-Specific Belief Questionnaire								
Buehl et al., 2002	*Study I:* 181 Ungrd *Study II:* 633 Ungrd	USA	*Domain-Specific Belief Questionnaire* (DSBQ) • Developed to assess domain-specific epistemological beliefs • Based on the SEQ • Items identical for two domains, mathematics and history	*Study I* Items dropped if means not comparable across forms of preliminary instrument EFA • Principal axis factoring of 44 items • Extraction – eigenvalues > 1; scree plot	Integration of Information and Problem-Solving in Mathematics (6, Study II: .70, Study III: .69)	L	S	Y
					Need for Effort in Mathematics (5, Study II: .68, Study III: .72)	L	S	

Study III: 523 Ungrd	• *Study I:* 81 items • *Study II:* 50 items • *Study III:* 22 items • 10-point scale	• Varimax and oblimin rotation conducted, oblimin reported • 33.30% of variance explained by 2 factors • Loadings > .40 *Studies II & III* CFA • EQS • Revised items given to new samples • Assessed a 4-factor domain-specific model and compared it to alternative models (Study II) • Confirmed structure with a third data set (Study III) and compared it to alternative models • 4-factor model fit statistics ◦ Study II – CFI = .93; GFI = .94; AGFI = .92; SRMR = .05; RMSEA = .05; χ^2 (184) = 426.40 ◦ Study III – CFI = .88; GFI = .91; AGFI = .88; SRMR = .06; RMSEA = .06; χ^2 (184) = 521.60	Integration Information and Problem-Solving in History (6, Study II: .75, Study III: .65) Need for Effort in History (5, Study II: .61, Study III: .58)	L L	S S

(continued)

Table 4.1 (continued)

Author(s), Year	N Ed.Level	Country	Measure Details	Analysis	Factor Labels (No. of items/subsets[a], α)	Description[b]	Items[c]	Coefficients[d]
AGE GROUP								
Multidimensional Conceptualization of Beliefs Used to Frame Measure								
Measure								
Hofer and Pintrich (1997) Conceptualization								
Discipline-Focused Epistemological Beliefs Questionnaire								
Hofer, 2000	326 Ungrd	USA	*Discipline-Focused Epistemological Beliefs Questionnaire* (DEBQ) • Designed to assess the four belief dimensions posited by Hofer and Pintrich (1997) • Each item refers to a specific field of study as a frame of reference • Administered separately for psychology and science • 27 items per domain • 7-point scale	EFA • Analyses conducted separately for each discipline (i.e., psychology and science) • Principal components and maximum likelihood factoring of items • Extraction – eigenvalues > 1;scree plot • Varimax rotation • Loadings > 40 except for one item that loaded .32 • Reported cross-loadings greater than .30	Certain/Simple Knowledge (8, psychology: .74; science: .81)	R	A	Y
					Justification for Knowing: Personal (4, psychology: .56; science: .61)	D	A	
					Source of Knowledge: Authority (4, psychology: .51; science: .64)	D	A	
					Attainability of Truth (2, psychology: .60; science: .75)	D	A	
Braten et al., 2005	157 Ungrd	Norway	*Internet-Specific Epistemological Questionnaire* (ISEQ) • Developed based on Hofer and Pintrich's (1997) model of personal epistemology	Inter-item correlations used to drop items EFA • Maximum likelihood exploratory analysis of 28 items	General Internet Epistemology (14, .90) (no reverse coded items)	D	A	Y

			• 36 items • 10-point scale	• Extraction – forced 4-factor solution not interpretable, relative size of eigenvalues, scree plot • Oblique rotation • 47% of variance explained • Loadings > .40 and overlap < .20 • 18 items retained CFA • LISREL • Same sample as EFA • Tested 2-factor model with 18 items • 2-factor model fit statistics –CFI = .95; GFI = .86; AGFI = .82; RMSEA = .067; χ^2 (134) = 240.63	Justification for Knowing (4, .70) (all reverse coded items)	D	A	
Karabenick & Moosa, 2005	151 Ungrd 251 Ungrd	USA Oman	Epistemology Survey • Based on the Hofer and Pintrich model of personal epistemology • Items framed to reflect beliefs about science knowledge • Omani version backtranslate • Detailed discussion of alterations made in translation • 35 items • 5-point scale	EFA • Principal components analysis of items conducted separately by country • Extraction – forced a 4-factor structure • Varimax rotation • % of variance not reported • Loadings > .40 • Scale refinement conducted to improve reliability • Factor loadings and internal consistency reported as comparable across countries	Simple Knowledge (4) Certain Knowledge (4) Justification (4) Source (3) αs *ranged from .44 to .70 but not reported for individual factors*	D D D D	A A A A	Y

(continued)

Table 4.1 (continued)

Author(s), Year	N Ed.Level	Country	Measure Details	Analysis	Factor Labels (No. of items/subsets[a], α)	Description[b]	Items[c]	Coefficients[d]
AGE GROUP								
Multidimensional Conceptualization of Beliefs Used to Frame Measure								
Measure								
Alternative and Combined Conceptualizations								
Connotative Aspects of Epistemological Beliefs								
Bartholome et al., 2006	650 Ungrd	Germany	*Connotative Aspects of Epistemological Beliefs* (CAEB) semantic differential measure • 14 adjective pairs	EFA • Referred to Stahl and Bromme (submitted) for details of analysis • 49.62% of variance explained	Texture of Knowledge (7, .83) Variability of Knowledge (5, .67) Genesis of Knowledge (2, .28)	D D D	X X X	N
Items Combined from Multiple Sources								
Hofer, 1999	438 Ungrd	USA	Items based on Lampert (1990) and Schoenfeld (1992) • Developed to "reflect the degree to which students hold simplistic beliefs about mathematical knowledge, such as the importance of being able to get a right answer quickly, or that mathematics learned in school has little value or application" (p. 76–77) • Six items • Scale not reported	EFA • Factor analysis of items • Extraction – eigenvalues>1 • Varimax rotation • 44.3% of variance explained • Loading criterion not reported	Simple Beliefs (3, .48) Isolated Beliefs (3, .41) Used total score from both scales in analyses (6, .54)	L L	S S	N

Wood & Kardash, 2002	793 Ungrd & Grad	USA	Items from SEQ (Schommer, 1990) and JEQ (Jehng et al., 1993) • 80 items (58 from SEQ and 22 from JEQ) • 5-point scale	Inter-item correlations less than .10 used to drop items EFA • Principal axis factoring of items • Extraction – eigenvalue>1, scree plot • Examined solutions for maximum likelihood, principal components, and generalized least squares extractions with promax, varimax, oblimin, and quartimax rotations; promax rotation reported • 22.05% of variance explained • Loadings > .35 with overlap on other factors < .25	Speed of Knowledge Acquisition (8, .74)	D	A	Y
					Structure of Knowledge (11, .72)	D	A	
					Knowledge Construction and Modification (11, .66)	D	A	
					Characteristics of Successful Students (5, .58)	D	A	
					Attainability of Truth (3, .54)	D	A	
Buehl & Alexander, 2005	482 Ungrd	USA	Items from DSBQ (Buehl et al., 2002) and DFEBQ (Hofer, 2000) • DSBQ items related to the isolation of knowledge and DFEBQ items related to the certainty of knowledge and authority as the source of knowledge • Domain specific to mathematics and history • # items not reported • 10-point scale	CFA • Referred to Buehl and Alexander (2004) for all details for CFA	Isolation of History Knowledge Beliefs (.77)	D	S	N
					Certainty of History Knowledge Beliefs (.70)	D	S	
					Authority as the Source of History Knowledge (.74)	D	S	
					Isolation of Mathematics Knowledge Beliefs (.77)	D	S	
					Certainty of Mathematics Knowledge Beliefs (.70)	D	S	
					Authority as the Source of Mathematics Knowledge (.74)	D	S	

(continued)

Table 4.1 (continued)

Author(s), Year	N Ed.Level	Country	Measure Details	Analysis	Factor Labels (No. of items/subsets[a], α)	Description[b]	Items[c]	Coefficients[d]
			AGE GROUP					
			Multidimensional Conceptualization of Beliefs Used to Frame Measure					
Measure								
			SECONDARY STUDENTS					
			Schommer (1990) Conceptualization					
Schommer Epistemological Belief Questionnaire								
Schommer, 1993	1182 9th–12th grade	USA	SEQ (1990) • Adapted (i.e., slight re-wordings) for high school students based on pilot study • # items not reported, 12 subsets • 5-point scale	EFA • Principal factoring of 12 item subsets • Extraction – eigenvalues > .98 (> 1 rule resulted in 3 factors) • Varimax rotation • 53.3% of variance explained • Loading criterion not reported CFA • Footnote mentions that CFA was used to compare the fit of a 3-factor model and a 4-factor model • 4-factor model reported to fit better but fit statistics were not provided	Simple Knowledge Certain Knowledge Fixed Ability Quick Learning α*s reported as ranging from .45–.71 but not associated with specific factors*	D D D D	X X S X	Y

Qian & Alvermann, 1995	212 9th–12th grade	USA	SEQ (Schommer & Dunnell, 1992) • Omniscient Authority items not administered • 53 items • 5-point scale	EFA • Principal axes factor analysis of 53 items • Extraction – examined properties of 2- thru 5-factor solutions; selected 3-factor solution based on theoretical rationale and eigenvalues > 1 • Varimax rotation • 23% of variance explained • Loadings > .30	Quick Learning (15, .79) Simple-Certain Knowledge (11, .68) Innate Ability (6, .62)	D D D	X X X	N
Clarebout & Elen, 2001	124 15–17 year olds	5 countries in Europe	SEQ (Schommer, 1990) • Translation *not* reported • 12 items selected by Schommer (3 items each for certain knowledge, fixed ability, simple knowledge, and quick learning) • 5-point scale	EFA • Principal component analysis of items • Extraction – eigenvalues > 1, scree plot • No rotation reported • 54.44%of variance explained • Loadings > .50 and on only one factor	Truth for Scientist (2, .56) Effort Pays (1)	L L	X X	N
Cano, 2005	1600 Middle-high school (ages 12–18)	Spain	SEQ (Schommer, 1993) • Adapted into Spanish in collaboration with Schommer • # items not reported • Scale not reported	EFA • Principal components analysis (unclear if analysis conducted on items or subsets) • Extraction – eigenvalues > 1 • Varimax rotation • 42% of variance explained • Loading criterion not reported CFA • LISREL • Same sample • 3-factor model fit statistics – GFI = .95; AGFI = .92; RMR = .021; χ^2 (48) = 408.58	Quick, Effortless Learning (.64) Simple Knowledge (.60) Certain Knowledge (.42)	DS R R	X X X	N

(continued)

Table 4.1 (continued)

Author(s), Year	N Ed.Level	Country	Measure Details	Analysis	Factor Labels (No. of items/subsets[a], α)	Description[b]	Items[c]	Coefficients[d]
AGE GROUP								
Multidimensional Conceptualization of Beliefs Used to Frame Measure								
Measure								
Jehng's Epistemological Questionnaire								
Youn et al., 2001	455 10th–12th grade	Korea	JEQ (Jehng et al., 1993) • Translated into Korean • 61 items • 6-point scale	Items dropped if item-total correlations less than .10 EFA • Principal axis factor analysis of items • Extraction – scree plot • Varimax rotation • 24.58% of variance explained • Loading criterion not reported	Knowledge (13, .67) Learning (12, .75)	DS DS	X X	N
ELEMENTARY AND MIDDLE SCHOOL STUDENTS								
Schommer (1990) Conceptualization								
Schommer Epistemological Belief Questionnaire								

Schommer-Aikins et al., 2000	1269a 7th–8th grade	USA	SEQ (Schommer, 1990, 1993, 1998) • "[R]evised to have fewer items and, if necessary, simpler expression of ideas to more appropriate for middle school students" (p. 122) based on prior findings with SEQ and pilot study with middle school students • 30 items • 5-point scale	CFA • AMOS • Split sample • Assessed hypothesized 4-factor model with items assigned to one factor each • Poor fit for the 4-factor model • Items removed based on fit statistics and low loadings • 3-factor model fit statistics ◦ Modified model – CFI = .98; GFI = .98; RMR = .038; χ^2 (41) = 66.19; χ^2/df = 1.61 ◦ Replicated model – CFI=.97; GFI = .98; RMR = .044; χ^2 (41) = 81.43; χ^2/df = 1.98	Speed of Learning (4) Ability to Learn (5) Stability of Knowledge (2)	L L L	A A A	Y
Schommer-Aikins et al., 2005	1269a 7th–8th grade	USA	SEQ – Middle School version: • "[C]onstructed using the high school and college versions… (Schommer, 1990, 1993, 1998)" (p. 393) • Referred to Schommer et al. (2000) for details of scale development • 30 items • 5-point scale	EFA • Factor analysis of items • Extraction – factor loadings; scree plot • Varimax rotation • 40.35% of variance explained • Loadings > .30	Quick/Fixed Learning (10, .77) Studying Aimlessly (7, .55) Omniscient Authority (2, .55) Certain Knowledge (2, .36)	L L L L	A A A A	Y

(continued)

Table 4.1 (continued)

Author(s), Year	N Ed.Level	Country	Measure Details	Analysis	Factor Labels (No. of items/subsets[a], α)	Description[b]	Items[c]	Coefficients[d]
AGE GROUP								
Multidimensional Conceptualization of Beliefs Used to Frame Measure								
Measure								
Mason, 2000	343 8th grade	Italy	SEQ (Schommer, 1990) • Translated and adapted by Mason (1998) • 60 items, 12 subsets • 5-point scale	EFA • Principal axis factoring of 12 item subsets • Extraction-eigenvalues > 1 • Varimax rotation • 48.8% of variance explained • Loadings > .35	Quick Learning (3 item subsets)	R	X	Y
					Externally Controlled Learning (4 item subsets)	R	X	
					Certain Knowledge Handed Down by Authority (2 item subsets)	R	X	
					Simple Knowledge (2 item subsets)	R	X	
Jehng's Epistemological Questionnaire								
Lin, 2002	1240 4th–6th grades	Taiwan	JEQ (Jehng et al., 1993) • Translated into Chinese • Revised for elementary students • 61 items • 6-point scale	Inter-item correlations used to drop items EFA • Principal factoring of 55 items • Extraction – eigenvalues > 1 • Oblimin rotation • 54% of variance explained • Loading criteria not indicated	First Time Learning	D	X	N
					Omniscient Authority	D	X	
					Quick Learning	D	X	
					Simple Learning	D	X	

			Alternative Multidimensional Belief Measures and Conceptualizations					
Beliefs about Science Knowledge								
Elder, 2002	211 5th grade	USA	Likert-scale items • Addressed "issues of changing nature of science, role of experiments in doing science, coherence of science knowledge, and authority figures and materials as sources of scientific ideas" (p. 352) • 25 items • 5-point scale	Items conceptually grouped based on theory Reliability analysis and multidimensional scaling to confirm structure	Changing Nature of Science (9, .67) Role of Experiments and Source of Knowledge (6, .52) Source of Knowledge (4, .64)	D D D	S S S	–
Conley et al., 2004	187 5th grade	USA	Adapted items from Elder (2002) to assess beliefs about science • 26 items • 5-point scale	CFA • LISREL • Items assigned to factors • 4-factor model fit statistics ∘ *Time 1* – CFI = .90; NNFI = .89; RMSEA = .038; RMR = .062; χ^2 (293) = 396.39; χ^2/df = 1.61 ∘ *Time 2* – reported as similar to Time 1	Source (5, *T1*: .81, *T2*: .82) Certainty (6, *T1*: .78, *T2*: .79) Development (6, *T1*: .57, *T2*: .66) Justification (9, *T1*: .65, *T2*: .76)	D D D D	S S S S	N

[a] Refers to items unless otherwise stated.

[b] D indicates that factors were explicitly defined; DS indicates that factors were defined by listing the item subsets associated with the factor; R indicates the factors were defined by referencing a previous work; L indicates that only a label was provided for the factor with no description.

[c] A indicates all items were provided; S indicates selected or sampled items were provided; X indicates that no sample items were provided.

[d] Y indicates that structure coefficients were provide; N indicated that structure coefficients were not provided.

sense of the developments within the literature over time but was later reorganized to represent specific patterns in the published studies. Recorded sample characteristics include the size of the sample, grade level, and country/culture. With respect to the measures, when possible, I used the title developed by the authors or the title adopted by other researchers. For example, Jehng et al. (1993) developed a measure of beliefs using items from the SEQ and an unpublished measure developed by Spiro (1989). Although they do not name the measure other than to say that it is an epistemological belief instrument, several others (e.g., Cole et al., 2000; Youn, 2000) have used the measure in their research and referred to it as *Jehng's Epistemological Questionnaire*. I refer to the measure by Jehng et al. in the same way. If a name was not available for a specific assessment, I simply described the measure or items using the information provided by the authors (e.g., Elder, 2002; Hofer, 1999). Additionally, for each entry, I noted the number of items, type of Likert scale, and any modifications that were reported by the authors (e.g., translation, item revision).

I also present detailed information with respect to how the data were analyzed. General categories of data analysis procedures include exploratory factor analysis and confirmatory factor analysis. Because a variety of procedures, techniques, and criteria may be used with respect to the different types of analysis, I recorded information that is commonly reported. For instance, for exploratory factor analyses, the type of factor analysis reported by the authors was recorded as well as rotation procedures, whether the items or item subsets were analyzed, procedures used to identified the number of factors to extract, criteria to used assign items (or subsets) to factors, and the amount of variance explained by the selected factor structure.

Finally, for each identified factor, I recorded the label used by the authors, the number of items or item subsets related to it, the reliability coefficient of the data associated with each factor, as well as whether a description of the factor and sample items were provided. In many investigations, that the authors provided an explicit description or definition of the factors they identified (D; Table 4.1). However, in other cases, the authors more implicitly defined the factors by listing the item subsets associated with the factors (DS), provided a reference to a previous work (R), or provided only the label they selected for the factor (L). With respect to the specific items, in some investigations, the authors provided all of the items or subsets related to a particular factor (A) whereas in other works the authors provided selected sample items or subsets (S) or none at all (X). Further, some authors indicated the structure of their data by providing the coefficients or loadings associated with their items (or item subsets) and identified factors (Y) whereas others did not provide this information (N).

4.6 Summary of Study Characteristics

In the following sections, I discuss patterns and trends related to each of the recorded characteristics. Although I discuss each separately, each decision made by the authors may influence the belief factors that were identified. Thus, in the discussion of the identified factors, aspects of the sample, measure, and analyses are also considered.

In total, 37 published studies were examined, representing 42 student samples (i.e., several studied collected and analyzed data from more than one sample). The number of student samples excludes the duplicate sample introduced by including Schommer-Aikins et al. (2000) and Schommer-Aikins et al. (2005).

4.6.1 Participants

Following from Perry's initial work (1970), much of the literature related to epistemic beliefs has focused on university students, typically at the undergraduate level. This trend is seen in the assessment of students' multidimensional beliefs as well. Indeed, 32 of the reported samples consisted of undergraduates or a combination of undergraduate and graduate students. There were four examinations of high school students, three of middle school students (i.e., seventh and eighth grades; two based on the same sample), and three of elementary students in the fourth through sixth grades. Additionally, one investigation, included students ranging from early adolescence (i.e., age 12) to young adulthood (i.e., 18; Cano, 2005). In these instances, the differences in the emergent belief structures may be due to developmental changes within individuals. Given the importance of developmental issues in the study of individuals' beliefs about knowledge, I chose to order the entries in Table 4.1 based on the age level of the participants.

Additionally, the majority of the students sampled in the investigations I identified were from the USA. In more recent years, the study of epistemic beliefs has expanded to studies from other countries including Australia, Ireland, Norway, Belgium, five unidentified European countries, Germany, the Netherlands, Spain, Korea, Hong Kong, Taiwan, and Oman. The exploration of multidimensional beliefs in varied cultures is needed and should be applauded. However, issues related to culture need to be carefully considered with respect to selecting or modifying a measure and interpreting the emergent factors. Indeed, as evidenced in several investigations (e.g., Chan & Elliott, 2002; Clarebout et al., 2001), the expected factor structure was not identified when measures developed in the USA were used in other countries.

4.6.2 Measures

Belief conceptualizations employed. As indicated in Table 4.1, the majority of investigations have assessed beliefs using a version of the SEQ, the measure Schommer (1990) developed to assess her five proposed belief dimensions. Typically, for this measure, students respond to 63 items, organized into 12-item subsets, using a 5-point Likert scale. However, there were instances in which a shortened version of the SEQ was administered with 12–53 items, representing 8- to 11-item subsets (e.g., Kardash & Scholes, 1996; McDevitt et al., 1994).

In those studies that did not use the SEQ, the alternative measure was often related to the SEQ and Schommer-Aikins' conceptualization of beliefs. For instance, the Jehng et al.'s measure (1993), the JEQ, the EBI (e.g., Schraw et al., 2002), and the DSBQ (Buehl et al., 2002) were based, in part, on Schommer's proposed dimensions and the SEQ. The JEQ, or modified versions based on it, has been administered with 51–74 items and a 6-point or 7-point Likert scale (Jehng et al., 1993). The EBQ has been administered with 28–32 items and a 5-point Likert scale (Bendixen et al., 1998; Schraw et al., 2002). In its final form, the DSBQ consisted of 22 items used to assess two beliefs factors in two distinct domains (i.e., 11 items per domain). For the DSBQ, students responded to a 10-point Likert scale in an effort to increase variability in the data.

In contrast, to the JEQ, EBI, and DSBQ, Hofer's (1999) measure, the *Discipline Focused Epistemological Belief Questionnaire* (DFEBQ), was not derived from the SEQ. Instead, the DFEBQ is a domain-specific measure based on Hofer and Pintrich's (1997) proposal of four belief dimensions related to the certainty of knowledge, simplicity of knowledge, source of knowledge, and justification for knowledge. For the DFEBQ, students responded to 27 items per domain using a 7-point Likert scale (Hofer, 2000). Hofer and Pintrich's framework was also used in recent measures developed by Braten et al. (2005) and Karabenick and Moosa (2005).

Additional alternatives to Schommer's (1990) framework include items developed or adapted to address beliefs about knowledge in a specific domain (e.g., Elder, 2002; Hofer, 1999) and the *Connotative Aspects of Epistemological Beliefs* (CAEB) measure. As reported by Bartholome et al. (2006), the CAEB is a semantic differential measure. However, the authors provide only limited information about the factor structure of the data from the CAEB, instead referring the reader to a manuscript submitted for publication. At the time this chapter was written, the manuscript detailing the analysis of the data from the CAEB had not been published.

Further, some investigations have used a combination of items from existing measures. For instance, Wood and Kardash (2002) conducted an analysis of responses to items from both the SEQ and JEQ. In a recent investigation, Alexander and I selected items from both the DSBQ and DFEBQ to assess the belief dimensions we wanted to examine in relation to students' motivation (Buehl & Alexander, 2005).

Modifications. In addition to the basic frameworks used to develop the measures, modifications to these measures also need to be considered. As noted, shortened versions of the SEQ have been used by several researchers (e.g., Clarebout et al., 2001; Kardash & Scholes, 1996; Mori, 1999). Typically, authors have reported that items related to specific dimensions were used and provided the total number of items. Deleting items from a measure may influence the belief factors that emerge, particularly when other variables are modified as well.

Other modifications to existing measures include rewording items to make them appropriate for younger student populations and translating the items into another language. That is, to assess the beliefs of elementary, middle, or high school students, items have been revised to be simpler and to use language that is more familiar to the students (e.g., Schommer-Aikins et al., 2000). Translation is an issue when measures are administered to students in non-English speaking countries. In particular, backtranslation is recommended to ensure that the intended meaning of the item is maintained (Mertens, 1998). Specifically, the translated materials are translated back to the original language and the meaning of the items is compared. Of the 10 studies involving English measures and non-English speaking samples, two reported using backtranslation, seven reported that the measure was translated with no mention of backtranslating, and one study did not mention issues of translation at all. Further, in two investigations (i.e., Cano, 2005; Clarebout et al., 2001) the authors noted that item translation was conducted in collaboration with the author of the original measure (i.e., Schommer in both cases). In most cases, the item modifications, either for younger populations or translation to another language, were not discussed in detail. One exception for this was Karabenick and Moosa (2005), who gave a detailed discussion of the decisions and word choices that were made in translating their measure from English to Arabic.

Domain specificity. Measures also vary with their level of specificity. That is, whereas some measures assess beliefs about knowledge as a general construct (e.g., SEQ, JEQ, and EBI), others focus on beliefs about knowledge relative to a particular academic domain (e.g., DSBQ, DFEBQ). Based on the publication dates and frequency of domain-specific measures, there appears to be growing interest in students' domain-specific knowledge beliefs within this body of literature. Specifically, the first documented multidimensional epistemic belief measure was in 1990. The first multidimensional measure of individuals' beliefs about domain-specific academic knowledge was published in 1999 (i.e., Hofer, 1999) with eight additional works published between 2000 and 2006.

Academic knowledge beliefs that have been assessed include science (i.e., Conley et al., 2004; Elder, 2002; Hofer, 2000; Karabenick & Moosa, 2005, Lin, 2002), mathematics (i.e., Buehl et al., 2002; Buehl & Alexander, 2005; Hofer, 1999), psychology (i.e., Hofer, 2000), and history (e.g., Buehl et al., 2002; Buehl & Alexander, 2005). Most recently, Braten et al. (2005) developed a measure to assess students' beliefs about knowledge from the internet (i.e., *Internet-Specific Epistemological Questionnaire, ISEQ*). Thus, measures have been developed to assess knowledge in a variety of domains. Further, some of these measures (e.g., DSBQ and DFEBQ) were developed such that they can be easily adapted for other domains.

4.6.3 Analyses

The type of analyses researchers use to examine the structure of students' beliefs may also contribute to the number and nature of the identified belief factors. Out of the 37 published works I identified and included in the table, 24 employed only exploratory factor analytic (EFA) techniques to examine the structure of individuals' knowledge beliefs, five used only confirmatory factor analysis (CFA), seven used both EFA and CFA procedures, and one relied on multidimensional scaling.

Further, nine studies reported examining inter-item correlations and dropping items based on their correlations before conducting other procedures.

Exploratory factor analytic procedures. Of the 31 publications that reported using EFA procedures, the majority of the analyses were conducted on the item scores whereas eight analyses were conducted on subset composite scores and for two investigations it is not clear if subset scores or individual items were analyzed. The analysis composite scores instead of items is one of the criticisms of Schommer's (e.g., 1990) initial work (e.g., Hofer & Pintrich, 1997; Qian & Alvermann, 1995). That is, Schommer grouped items conceptually without empirical evidence that they were related. Subsequently, she, and others following her procedures and recommendations, analyzed the subset composite scores. In some cases, only one item subset was associated with a factor and there was some variability in how the item subsets were related to Schommer's proposed factors (Clarebout et al., 2001; Hofer & Pintrich, 1997). As seen in Table 4.1, studies that analyzed the item subset scores typically did not report reliability coefficients for the data. Additionally, in some cases, researchers reported conducting an analysis of the item subsets but when the anticipated factor structure did not emerge, they reanalyzed the data using the individual items (e.g., Clarebout et al., 2000).

In conducting EFA, there are various procedures and guidelines related to determining the number of factors to extract, extracting the factors, and interpreting the emergent solution. With respect to determining the number of factors to extract, there are numerous methods one can use (e.g., Gorsuch, 1983; Thompson & Daniel, 1996; Zwick & Velicer, 1986). As detailed in Table 4.1, eigenvalues, representing the amount of variance explained by each factor (Loehlin, 1998), were often examined to determine how many factors to extract. Specifically, the eigenvalue greater than one criteria, sometimes referred to as the Guttman-Kaiser rule (Loehlin, 1998), was typically used either alone or in combination an examination of the scree plot (i.e., a plot of the eigenvalues). Researchers also reported using previous research and theory to determine the number of factors they extracted (e.g., forcing a 4- or 5-factor solution based on Schommer's identified or proposed dimensions, Kardash & Scholes, 1996; Qian & Alvermann, 1995). This approach was used alone (e.g., Nussbaum & Bendixen, 2003; Karabenick & Moosa, 2005) or in combination with an eigenvalue criteria (e.g., Qian & Alvermann, 1995; Schommer et al., 1992). Although the eigenvalue greater than one rule is common, in many cases it results in more factors than are theoretically meaningful (Loehlin, 1998). In their overview of factor analytic methods, Thompson and Daniel (1996) recommend using Horn's parallel analysis or a bootstrapping method to determine the number of factors to extract. These procedures were not used in any of the investigations reviewed for this chapter.

Once the number of factors to extract has been determined, one needs to extract the factors. There are several methods of factor extraction available. Two commonly cited methods are principal components analysis and principal factor analysis. The use of these methods has been debated as there are differences with respect to how the data are analyzed (e.g., Thompson & Daniel, 1996). Further, principal components analysis has been noted as being useful for simplifying data and forming composite variables whereas principal factor analysis is more appropriate for identifying an underlying latent factor model (Dunteman, 1989). However, when there are 30 or more variables to be analyzed, the results of the two methods are similar (Gorsuch, 1983). In the works I reviewed, eight reported using principal components analysis, 21 reported using principal factor analysis, two reported using another method, and in two studies it was unclear what type of analysis was conducted. Further, included in these numbers are three studies that conducted two or more different analyses (e.g., principal components analysis and maximum likelihood) but only reported the results from one.

In conducting an EFA, researchers often use rotation to interpret the emergent factors (e.g., Dunteman, 1989; Gorsuch, 1983; Thompson & Daniel, 1996). There are two major types of rotation: orthogonal rotation in which factors are unrelated and nonorthogonal, or oblique, rotation in which factors are allowed to correlate (e.g., Gorsuch, 1983; Loehlin, 1998). Varimax rotation (Kaiser, 1954) is a common orthogonal rotation (Dunteman, 1989) whereas quartimax and equamax are additional orthogonal rotation techniques that can be used (Gorsuch, 1983). Oblique procedures include direct oblimin, promax, and quartimin rotations (Gorsuch, 1983; Loehlin, 1998). To the extent the factors are indeed unrelated, solutions from both orthogonal and oblique rotations will be similar.

In my review, varimax rotation was most commonly reported. However, there were instances in which the authors indicated that both orthogonal and oblique rotations were employed but the factor coefficients related to one were reported, again typically for the varimax rotation. Reasons cited for the use of the varimax rotation include a desire to replicate Schommer's (1990) procedures (i.e., she conducted both varimax and oblique rotations but only reported the varimax results; e.g., Kardash & Scholes, 1996; Mason, 2000; Qian & Alvermann, 1995;) as well as obtaining similar results with both the orthogonal and oblique rotations (e.g., Bendixen et al., 1998; Chan & Elliott, 2000). When researchers offered a rationale for using oblique rotation, it was typically based on the theoretical grounds that it is reasonable to assume that individuals' beliefs about knowledge may be related (e.g., Braten et al., 2005; Nussbaum & Bendixen, 2003) or because the oblique rotation provided a more interpretable factor structure (e.g., Mori, 1999).

Finally, in EFA, criteria need to be established for assigning items to factors. The structure coefficients, often referred to as loadings, represent the correlation between each item and the factor or component. (Thompson and Daniel (1996) advise against using the term "loading" to refer to the factor coefficients, instead recommending the terms pattern coefficients, structure coefficients, or pattern/structure coefficients depending on the form of rotation employed and the coefficients being referred to. Here, I attempt to follow their recommendations. However, in the studies I reviewed, the term "loading" was often used.) In exploratory factor analysis, items are often assigned to a factor if the structure coefficient meets or exceeds a cutoff criterion. Although suggestions are made as to appropriate structure coefficient criteria, they are only rough guidelines (e.g., Gorsuch, 1983). My review of studies examining the dimensionality of students' knowledge belief revealed that a variety of cutoff ranging from .30 to .50, with .30 and .40 being the most common. Further, there were only 10 instances in which researchers indicated criteria for items that were related to more than one factor, sometimes referred to as double or cross-loadings. What is perhaps more troubling is that in seven instances the criteria value was not indicated. This lack of information makes it difficult for others to replicate analysis procedures and compare results in future investigations.

Confirmatory factor analysis procedures. In contrast to EFA, researchers presented limited detail with respect to the procedures used in CFA. This is unfortunate as various programs and methods may be used. The information that was reported in the studies I reviewed included the program used to conduct the CFA, how items were grouped or assigned to factors, fit statistics, and problems that arose in model testing. As noted in Table 4.1, 10 of the 12 investigation using CFA reported fit statistics associated with the final model but there was some variation in the specific fit statistics that were reported (e.g., CFI, GFI, RMSEA). Further, although many readers may not be familiar with CFA, only three investigations (i.e., Buehl et al., 2002; Schommer et al., 1992; Schommer-Aikins et al., 2000) provided criteria to interpret the fit statistics. Other investigations reporting CFA fit statistics made blanket statement about the fit (e.g., "the model has moderately good fit"). Thus, there is not a great deal of consistency with respect to the information the reader has to evaluate the presented results, particularly if one is unfamiliar with acceptable fit statistics in CFA.

Additionally, my review indicated that many researchers do not take advantage of the strengths associated with CFA. For instance, in the seven studies in which both EFA and CFA were employed, analyses were conducted on the *same* data in six instances. Only Buehl et al. (2002) conducted an EFA and CFA on separate samples. EFA, as the title implies, is more exploratory and data driven (Byrne, 1994; Gorsuch, 1983). In contrast, CFA is typically viewed as more theory driven, allowing the researcher to assign items to factors, test the hypothesized structure of the data, and statistically compare alternative models (Byrne, 1994; Gorsuch, 1983; Kim & Mueller, 1978). When EFA and CFA procedures are used on the same data, good model fit in the CFA is expected. Thus, the added strength of the CFA in testing a hypothesized structure for a new data set based on theory or previous findings is lost.

An additional benefit of CFA is the capability to test and compare alternative models (Thompson, 1997). Because CFA involves testing the fit of a hypothesized model to the data, it is also possible to fit alternative models to the data and compare the fit. However, in my review of the identified studies, only five reported testing models other than the final model presented (i.e., Buehl et al., 2002; Schommer et al., 1992; Schommer, 1993; Schommer-Aikins et al., 2000; Youn, 2000). In the other investigations (e.g., Cano, 2005; Conley et al., 2004; Cole et al., 2000; Jehng et al., 1993), although there may be evidence that the proposed model fit the data, it is unclear if there are other plausible models that may also fit the data.

Finally, sample size must be considered when using CFA as a considerable amount of data is needed to obtain reliable estimates (e.g., Bollen, 1989; Byrne, 1994). I observed two studies in which samples were small relative to the complexity of the models tested (e.g., Braten et al., 2005; Conley et al., 2004), raising some concerns about their findings. Most studies using CFA tended to have relatively large (i.e., 300+) samples. For example, Schommer-Aikins et al. (2000) took advantage of their large sample (i.e., 1269 students) by splitting it in half. An initial CFA model was developed based on one half of the data and then confirmed by applying it to the unused half the data. Such procedures provided additional support for the identified 3-factor solution. (However, given the strength of this analysis, it is unclear why the same data were later used in an EFA with different results (Schommer-Aikins et al., 2005).) Difficulty obtaining large samples may account for why others do not use CFA more often.

4.7 Identified Belief Factors

Given the variables that may influence the number and type of belief factors identified in previous works, tallying the specific factors that have been identified did not seem to be an effective way to represent this body of work. That is, the number of studies that used the SEQ or sampled university students from the USA may cause some belief dimensions to be over represented. Thus, I chose to look for general trends and examine the emergent belief factors relative the characteristics already discussed (i.e., sample characteristics with a particular emphasis on age and culture, as well as the measures employed).

4.7.1 A Potential Organizing Framework

I want to clarify that my purpose here is not to propose a new conceptualization of epistemic beliefs. Instead, I wanted to organize and describe the belief factors that have been identified in previous investigations. As previously noted, the five belief dimensions initially proposed by Schommer (1990) under gird many of the measures that have been created and the factors that have been identified. These dimensions pertain to beliefs about the certainty of knowledge, simplicity of knowledge, source of knowledge, speed of knowledge acquisition, and ability to learn. In contrast, Hofer and Pintrich (1997) questioned the inclusion of beliefs about learning and proposed four knowledge belief dimensions related to beliefs about the certainty of knowledge, simplicity of knowledge, source of knowledge, and justification of knowing. Further, they conceptualize beliefs about the certainty of knowledge and beliefs about the simplicity of knowledge under the heading of the *nature of knowledge* whereas source of knowledge and justification of knowing are grouped under the heading of the *nature of knowing*.

The factors I identified through this review provide general support for these proposed dimensions. Across studies, factors related to the proposed dimensions have been identified with some consistency. However, neither conceptualization fully captures the range of belief factors. The factors that were more difficult to "place" within the original conceptualizations contained aspects of the Schommer dimensions related to the speed of learning and individuals' ability to learn but also addressed beliefs about the processes through which knowledge is acquired, constructed, and or modified (e.g., Clarebout et al., 2001; Wood & Kardash, 2002). Chan and Elliott's (2004) proposed hierarchical multidimensional framework, an intentional integration of Schommer (1990) and Hofer and Pintrich (1997), appeared to offer an initial means to organize the various belief factors I identified in my review of the literature. Specifically, Chan and Elliott (2004) assert that there are two main facets to individuals' knowledge beliefs, beliefs about the nature of knowledge and beliefs about knowing, that consist of more specific belief dimensions.

Beliefs about the nature of knowledge. Beliefs about the nature of knowledge include beliefs about simplicity or complexity of knowledge, the degree to which knowledge is isolated or integrated as well as beliefs about the certain or changing nature of knowledge. In my review, factors reflecting such beliefs were identified in numerous investigations using different measures and student samples (e.g., simple knowledge: Karabenick & Moosa, 2005; Mori, 1999; Schommer, 1990; Schraw et al., 2002; structure of knowledge: Wood & Kardash, 2002; certain knowledge: Chan & Elliott, 2002; Karabenick & Moosa, 2005; Schraw et al., 2002; Schommer, 1990; Schraw et al., 2002; attainability of truth: Hofer, 2000; Mori, 1999).

Beliefs about the nature of knowing: Process of knowing. Beliefs about knowing consist of beliefs about the process of knowing *and* beliefs about factors that contribute to the process of knowing (Chan & Elliott, 2004). Beliefs about the process of knowing include beliefs about the source of knowledge and justification for knowing, as also proposed by Hofer and Pintrich (1997), as well as beliefs about the speed of knowledge acquisition (i.e., a belief dimension proposed by Schommer) and beliefs about the processes individuals use to acquire, construct, or modify knowledge. Belief factors related to these various aspects of the process of knowing have been identified in the investigations I reviewed (i.e., authority as a source of knowledge: Hofer, 2000; Jehng et al., 1993; justification for knowing: Braten et al., 2005; Karabenick & Moosa, 2005; knowledge construction and modification: Braten & Stromso, 2005; Wood & Kardash, 2002; avoidance of inferential processes: McDevitt et al., 1994; meaning is contextually created: Clarebout et al., 2001; orderly processes: Jehng et al., 1993; need for effort: Buehl et al., 2002; Clarebout et al., 2001).

Beliefs about the nature of knowing: Controlling and influencing factors. Based on Chan and Elliott's (2004) description, beliefs about features that control or influence knowing encompass beliefs about ability or other aspects of individuals' lives that may influence what they come to know. I viewed this as a heading that could include belief factors related to innate or fixed ability (e.g., Schommer, 1993;

Schraw et al., 2002) as well as other characteristics of student or environment that may contribute to the learning process. In particular, Wood and Kardash (2002) identified a factor reflective of characteristics of successful students and others have identified factors pertaining to externally controlled learning (e.g., Mason, 2000; Schommer et al., 1992).

4.7.2 Troubling Trends

Although Chan and Elliott's framework seemed to encompass the various belief factors that have been identified, as I looked more closely at the factors the messy nature of beliefs (i.e., Pajares, 1992) became apparent as well as the limitations imposed by the reporting practices employed by the various authors.

Reporting practices. Any missing data in the Table 4.1 were not provided by the authors. Specifically, in 10 out of 37 publications the number of item subsets was reported but not the items associated with those subsets. Additionally, in three studies, neither the number of items nor the number of item subsets were reported. In 12 out of 37 publications, the reliability coefficients associated with the data were not presented. For two additional works, the range of the reliability coefficients was reported but not directly connected to data from the specific factors (e.g., Karabenick & Moosa, 2005; Schommer, 1993). Without this information it is difficult to make comparisons across studies and, perhaps more importantly, to determine if the data reported in a particular investigation are reliable.

In my review, I also documented the labels given to the factors as well as how they were described. I was surprised to find how frequently, my own work included, descriptions of belief factors were either limited or not presented. Often, factors were labeled to represent one end of the continua (e.g., Buehl et al., 2002; Clarebout et al., 2001; Schommer, 1990; Schraw et al., 1995). Thus, it was possible to interpret the meaning of high or low scores on a particular factor. However, in other instances, labels were not indicative of how scores were to be interpreted (e.g., Cole et al., 2000; Schommer-Aikins et al., 2000; Youn, 2000). Further, some factor descriptions were little more than a restatement of the label (e.g., Buehl & Alexander, 2005; Qian & Alvermann, 1995; Schommer et al., 1992), simply listed the types of items or item subsets associated with the factors (e.g., Chan & Elliott, 2000; Youn et al., 2001), or implicitly defined the factor by referring to a previous publication (e.g., Bendixen et al., 1994; Cano, 2005; Mason, 2000).

In addition to describing the identified factors, including the items associated with a factor is also beneficial for the reader. As documented in Table 4.1, 13 of the 37 investigations published all items associated with each factor and 10 investigations published selected sample items whereas the remaining 14 did not provide any items. Further, 22 works included the coefficients depicting the relations between each item, or item subset, and the identified factors. The inclusion of the items, or item subsets, associated with a particular factor provides information with respect to the nature of the construct as well as how the construct may compare to others across studies. I found this information particularly useful when trying to identify trends across the various studies included in this review.

Interpretation and labeling of belief factors. Many belief factors reported are less clearly defined then their labels indicate, particularly when item subsets from the SEQ were analyzed instead of the individual items. That is, through exploratory factor analytic procedures, item subsets designed to address different belief dimensions have been associated with the same belief factors. For instance, cross-dimension item subsets associated with the same factor include subsets related to beliefs about the certainty of knowledge and beliefs about authority as the source of knowledge (e.g., Chan & Elliott, 2000; Kardash & Scholes, 1996; Schommer, 1992, 1993; Schommer et al., 1992), subsets related to beliefs about the speed of knowledge acquisition and beliefs about the ability to learn (e.g., Kardash & Howell, 2000; Schommer, 1990; Schommer et al., 1992), and subsets related to beliefs about the certainty of knowledge, beliefs about the ability to learn, and beliefs about authority as the source of knowledge (e.g., Kardash & Howell, 2000). Such combinations of beliefs were also apparent when analysis was conducted on the items from the SEQ or other measures (e.g., items related to beliefs certainty of knowledge and authority as the source of knowledge: Mori, 1999; Nussbaum & Bendixen, 2003; items related to beliefs about the certainty of knowledge and beliefs about the simplicity of knowledge: Hofer, 2000; Qian & Alvermann, 1995).

To a certain extent, the interrelated nature of individuals' knowledge beliefs should be anticipated. Beliefs are complex constructs to assess, particularly with Likert-scale items, and the dimensions are proposed to be interrelated (e.g., Chan & Elliott, 2004; Hofer & Pintrich, 1997; Schommer, 1990). However, the interpretation and labeling of factors is particularly troubling for two reasons. First, although the complexity of the belief factor may be addressed when the factor is first described, the nuances of a particular factor are quickly reduced to its label as additional analyses are conducted and results are reported. Thus, conclusions drawn related to the belief factor may not be valid. Second, in some investigations, the lack of information reported by the authors prevents the reader from making such determinations for him or herself. Instead, the reader must trust that the label and description provided are adequate representations of the data.

Another issue related to the interpretation of the identified belief factors pertains to the consistency or inconsistency of the labels themselves across investigations. Gorsuch (1983) noted that "[f]actors already well replicated in a standard area are often rediscovered and given a new name" (p. 372). Although one may argue if enough research has been conducted to establish any of the factors as well replicated or to view study of individuals' epistemic beliefs as a standard area, I found instances in which similar groups of items were given different labels.

Most notably, similar items related to "scientists' ability to get to the truth" were associated with each other across several investigations by different groups of researchers. The factor identified by these items was alternatively labeled attainment or attainability of truth (i.e., Hofer, 2000; Mori, 1999; Wood & Kardash, 2002), scientists know the truth or truth for scientists (i.e., Clarebout et al., 2001;

Clarebout & Elen, 2001), certain knowledge (i.e., Schraw et al., 2002), stability of knowledge (i.e., Schommer-Aikins et al., 2000), and omniscient authority (i.e., Schommer-Aikins et al., 2005). Although the items were almost identical, the labels given the factor have different connotations and in each study there was no acknowledgement that others have identified a similar factor. Further, this factor does not directly represent any of the proposed belief dimensions but only Hofer (2000) and Schraw et al. (2002) attempted an explanation. Specifically, Hofer (2000) noted that the attainability of truth items were conceptually related to the certainty of knowledge and stated that "future studies with the instrument are needed to see how consistently this factor [attainability of truth] appears" (p. 399). Schraw et al. (2002) offered a more extensive explanation when they analyzed data from the SEQ and identified two factors related to the certainty of knowledge (i.e., Certain Knowledge I and Certain Knowledge II). They suggested that the certain knowledge factor related to scientists discovering truth (i.e., Certain Knowledge I) pertained to the accessibility of certain knowledge whereas their second certain knowledge factor (i.e., Certain Knowledge II) represented the likelihood that certain knowledge exists.

The importance and utility of such a distinction is an issue for future investigation. However, this example underscores Gorsuch's (1983) points about reading the existing literature and being mindful of how factors are labeled. Additionally, the diversity of labels for essentially the same factor was only apparent because the authors provided the items in addition to the factor labels. There may be similar cases that are undetectable due to the lack of information provided in published works.

4.7.3 Identified Factors in Relation to Study Characteristics

Participant characteristics: Age and education. Beginning with Perry's initial work, there has been an assumption that individuals' beliefs about knowledge develop with age and education. The work by Perry and others taking a more unidimensional perspective of individuals' knowledge beliefs supports this assumption (Baxter Magolda, 1992; Belenky et al., 1986; King & Kitchener, 1994; Kuhn, 1991; Perry, 1970). Thus, given the developmental nature of epistemic beliefs, variations in the types of belief factors that were identified may be a function of the age or education level of the participants (Table 4.1).

Although most of the research has been conducted with college students, some studies examining the multidimensional beliefs of secondary and middle school students support this perspective. For instance, when Schommer-Aikins et al. (2000) administered the SEQ to seventh- and eighth-grade students, a 3-factor belief structure emerged, not the 4-factor structure previously identified with college students. Qian and Alvermann (1995) also identified a 3-factor solution in their work with high school students. One possible explanation is that students' knowledge beliefs become more differentiated with age. That is, in both investigations, students' beliefs about the certainty and simplicity of knowledge did not seem as differentiated as their beliefs about the speed of learning and the ability to learn.

However, there are contradictory findings across investigations. For instance, a 4-factor belief solution, with differentiated certainty and simplicity factors, was found in some high school student samples (Schommer, 1993). Additionally, Schommer-Aikins et al. (2005) appeared to use the same data as Schommer-Aikins et al. (2000) and identified four belief factors. Even so, previous issues related to analysis of data from the SEQ as well as low or missing reliability coefficients suggests that additional work is need before drawing substantive conclusions about the dimensionality of secondary and middle school students' knowledge beliefs.

In contrast, the three studies examining the beliefs of elementary students suggest that young students hold distinct views about different aspects of knowledge. Elder (2002) and Conley et al. (2004) both identified multiple belief factors in fifth grade students related to beliefs about the nature of science knowledge. Additionally, Lin (2002) identified four belief factors in a study with students from the fourth through the sixth grades. Although Lin did not report the reliability of her data, the reliability coefficients reported by Conley et al. (2004) suggest that even young students can provide consistent responses. Given the small number of studies, it is not possible to determine the extent to which the domain-specificity or generality of the measure used in each study may have contributed to the observed results.

Participant characteristics: Culture. As previously noted, the majority of the research has focused on student samples from the USA. However, 14 works included in this review were conducted with students from other countries in Europe, Asia, and the Middle East. In my literature search, I identified additional studies exploring individuals' knowledge beliefs in other countries that did not meet the criteria for inclusion in this review (i.e., conference papers, publications not available in English, application of factor structure without analyzing the data). Although these studies provide us the opportunity to examine the multidimensionality of beliefs in varied cultures, we also must recognize that this work is still in its infancy and is limited by existing belief conceptualizations and measures. That is, in most cases, researchers have used the Schommer (1990) or Hofer and Pintrich (1997) conceptualization of beliefs, often translating existing measures into another language. This may obfuscate the emergence of additional aspects or nuances of knowledge beliefs in other cultures.

As evidenced in several investigations (e.g., Chan & Elliott, 2002; Clarebout et al., 2001), the expected factor structure was not identified when measures developed in the USA were used in other countries. However, in many of these cases the identified factors were similar to beliefs factors identified with students from the USA (e.g., Jehng et al., 1993; Wood & Kardash, 2002). Thus, the unexpected findings may be more a function of problems with existing measures than cultural variations. The lack of information about identified factors as well as variations in the age of the participants (e.g., Cano, 2005; Lin, 2002; Mason, 2000) also limits the extent to which cultural variations can be identified and explored.

Despite these limitations, works by Chan and Elliott (2000, 2002), Youn (2000) and colleagues (Youn et al., 2001) and Karabenick and Moosa (2005) directly address the role of culture in the study of epistemic beliefs. Specifically, Chan and Elliott (2002) explored the beliefs of teacher education students in Hong Kong, Youn and his colleagues (Youn, 2000; Youn et al., 2001) addressed the beliefs of high school and college students in South Korea, and Karabenick and Moosa (2005) explored the beliefs of college students in Oman. Further, in the studies by Youn (2000) and Karabenick and Moosa (2005), students from the USA were also sampled for the purpose of making direct comparisons.

Chan and Elliott (2000, 2002) and Youn (2000; Youn et al., 2001) found that the structure of beliefs that emerged for students in Hong Kong and South Korea, respectively, differed from the belief structures previously identified with students from the USA. In contrast, although Karabenick and Moosa (2005) identified similar belief factor structures for college students in Oman and the USA, they found differences in the relations among the belief factors as well as extent to which students expressed beliefs related to the certainty of knowledge, the simplicity of knowledge, and authority as the source of knowledge. Further, gender appeared to moderate the differences by country.

These researchers all identified students' surrounding cultures as an explanation for variations in their beliefs. For instance, Karabenick and Moosa (2005) discussed the social, political, and religious features in Omani society that may influence males' and females' beliefs about scientific knowledge and account for differences in beliefs between students from Oman and the USA. Chan and Elliott (2002, 2004) referred to the Confucian heritage of the Chinese culture that values hard work and effort whereas Youn (2000) described how the student–teacher relationship in Korea differs from that found in the USA.

The work presented by Youn and his colleagues (Youn, 2000; Youn et al., 2001) is particularly interesting given the variations in beliefs identified across countries (i.e., South Korea and the USA) and age or education levels (i.e., college and high school). Specifically, when they assessed students' beliefs using the JEQ, they identified a 2-factor belief structure instead of the five factors identified by Jehng et al. (1993). Youn and colleagues (Youn, 2000; Youn et al., 2001) referred to the two factors as Learning and Knowledge (Table 4.1). Although a 2-factor solution also emerged in a comparison sample of college students from the USA (Youn, 2000), there were differences in how the various items were related to the two factors. Specifically, for Korean college students, items related to beliefs about the source of knowledge were associated with items related to the speed of learning and the innateness of ability (i.e., the Learning factor). In contrast, for the American sample, items related to the source of knowledge were associated with items related to the certainty of knowledge and the orderly process of knowing (i.e., the Knowledge factor), as Schommer-Aikins and others would predict (e.g., Cole et al., 2000; Schommer, 1994).

Youn (2000) suggested that the distinction between the learning and knowledge beliefs may be reflective of the personal nature of the learning beliefs (i.e., dimensions related to individuals' view of self) and the impersonal nature of the knowledge beliefs (i.e., dimensions related to knowledge and more distant from the self). He further explained that the observed variations in how items related to the source of knowledge may be due to differences in views of authority and the nature of the student–teacher relationship in Korean and the USA. That is, in Korea the student–teacher relationship is viewed as more personal and binding whereas in the USA the student–teacher relationship is viewed as more impersonal and freeing (Hofstede, 1986).

However, when the same measure was used to collect data from high school students, the two factors Youn et al. (2001) identified were more similar to those identified in the USA college students than the South Korean college students (i.e., source of knowledge items were associated with items pertaining knowledge, not learning). Youn et al. (2001) suggested these findings may reflect (1) that Korean high school students are not fully enculturated in mainstream Korean society, (2) subcultural differences between generations, or (3) the increased, and more impersonal, role of computers in Korean students' learning process.

Collectively, the works reviewed for this chapter suggest that the current conceptualization of beliefs may not capture the nature of knowledge beliefs in other cultures. Further, although not detailed here, I found that investigations that applied the factor structure identified in one country (i.e., the USA) to data collected another (e.g., China) reported low reliabilities associated with the belief factors (e.g., Qian & Pan, 2002). Consequently, it may not be appropriate to administer the current epistemic measures to individuals in other countries and examine group differences. Instead, we need to explore potential differences in the structure and nature of students' knowledge beliefs. Such explorations would include using statistical techniques (e.g., exploratory and confirmatory factor analysis) to determine the structure of individuals' beliefs as well as using interviews and more qualitative methods. Additionally, as Chan and Elliott (2002) and Youn (2000) discussed, some cultures are slowly changing due to the Western influence. Thus, the beliefs that emerge from future investigations may offer depictions of cultures in transition.

Measures. Given the various measures that have been used as well as the modifications made to them and differences in data analysis, it is difficult to draw substantive conclusions. The SEQ is, to date, the most extensively used measure but there is considerable variation in the factors identified with this measure. Such variations may be due to the data analysis procedures, background of the sampled participants, or the construction of the measure itself. Based on the reported information, the EBI appears to yield the most consistent factor structure and data from this measure tends to be reliable (e.g., Bendixen et al., 1998; Schraw et al., 1995; Schraw et al., 2002). However, the EBI has only been used with college students in the USA. Other measures have only been used in a small number of investigations (e.g., DSBQ, DEFBQ) or the sample characteristics varied too much to draw conclusions about the belief factors identified with the measure (e.g., JEQ). Thus, additional investigation is needed to determine how well these measures assess individuals' beliefs about knowledge. Although not a specific measure, Hofer and Pintrich's (1997) conceptualization of knowledge beliefs appears to be particularly promising as there has been some consistency in the factors identified from measures created based on this model.

4.8 Recommendations for Future Research

The studies reviewed for the chapter offer evidence of the multidimensional nature of epistemic beliefs. In particular, distinct belief dimensions were identified in students of varying ages and cultural contexts. However, there are also limitations and inconsistencies in the existing research. Thus, additional research is needed to more fully understand the nature of knowledge beliefs and how they relate to students' cognitive processing, learning, and motivation. Based on my review, I offer the following recommendations for future research in this area.

First, in future investigations of students' multidimensional knowledge beliefs, the structure of students' beliefs must be explicitly examined to determine if the hypothesized structure is appropriate, particularly if characteristics of the sample and measure differ from previous investigations. In my literature search, I rejected numerous studies that created belief composites based on a factor structure identified in a previous investigation. In some of these instances, low levels of reliability were reported. Further, given the concerns raised in this review, the belief composites created may not have been appropriate representations for the beliefs of a particular sample (e.g., elementary school students, Neber & Schommer-Aikins, 2002). It is important for researchers to continue to examine the dimensions of students' beliefs. If the sample size permits, confirmatory factor analysis would be particularly suited for this purpose. However, if the anticipated factor structure does not fit the data, additional analysis including EFA may be needed to identify belief factors that are reliable and valid. Further, I recommend using data from individual items rather than composites for item subsets. These recommendations are particularly important when examining beliefs of younger students and students from countries other than the USA.

Second, given the potential differences in beliefs that were identified for different age levels and cultural contexts, more attention to developmental and cultural differences in beliefs is needed. Researchers should continue to explore how beliefs about knowledge emerge and develop throughout the course of students' lives as well as how beliefs are related to formal and informal education experiences. Further, additional research is needed to understand how beliefs vary across cultural contexts. In my review, culture was broadly defined based on country or region of the world. Although such broad examinations may be informative, it is important to acknowledge and examine the various cultures and subcultures within specific countries and regions and consider additional contextual factors (e.g., socioeconomic status). It may also be fruitful to consider the features within individuals' environments that foster or promote specific views of knowledge. The understanding gained from such an analysis may offer additional insight into cultural differences and provide a greater understanding of the perspectives of others.

Third, future research needs to take full advantage of the sophisticated data analysis techniques that are available. This includes greater use of statistical procedures such as confirmatory factors analysis as a means to test the structure of beliefs and make comparisons across groups as well as the use of rigorous qualitative methodologies. Indeed, qualitative explorations of individuals' responses and behaviors may provide insight into additional aspects of individuals' beliefs within and across cultures.

Finally, I strongly recommend that we, as a field, be more detailed and consistent in our reporting practices when describing the studies we conduct. Details with respect to the measures employed and how they are modified as well as the procedures used to analyze the data are essential for understanding how a study was conducted and potentially replicating it in future work. Further, detailed information with respect to the factors that are identified, the items associated with the factors, and the reliability of data is necessary for the reader to understand the findings and judge the validity of the reported conclusions.

The study of beliefs, as Pajares (1992) noted in his review of teachers' beliefs, is a messy endeavor. However, the centrality of beliefs to individuals' actions and views of themselves cannot be overlooked or ignored. Within learning contexts, beliefs about knowledge are particularly important. In order to understand their influence, we need to ensure they are conceptualized and assessed in a meaningful way. In this chapter, I attempted to review studies that examined a specific subset of students' beliefs (i.e., multidimensional epistemic beliefs). In part, I wanted to understand the nature of these beliefs across cultural contexts. However, as discussed, variations in the ways beliefs have been assessed and the data analyzed, make it difficult to discern conclusive patterns. Consequently, my hope is that I have provided a depiction of previous work that can be used to guide and inform future research.

References

Bartholome, T., Stahl, E., Pieschl, S., & Bromme, R. (2006). What matters in help-seeking? A study of help effectiveness and learner-related factors. *Computers in Human Behavior*, 22, 113–129.

Baxter Magolda, M. B. (1992). *Knowing and reasoning in college: Gender-related patterns in students' intellectual development*. San Francisco, CA: Jossey-Bass.

Belenky, M. F., Clinchy, B. M., Goldberger, N. R., & Tarule, J. M. (1986). *Women's ways of knowing: The development of the self, voice, and mind*. New York: Basic Books.

Bendixen, L. A., Dunkle, M. E., & Schraw, G. (1994). Epistemological beliefs and reflective judgment. *Psychological Reports*, 75, 1595–1600.

Bendixen, L. A., Schraw, G., & Dunkle, M. E. (1998). Epistemic beliefs and moral reasoning. *The Journal of Psychology*, 132(2), 187–200.

Bollen, K. A. (1989). *Structural equations with latent variables*. New York: Wiley.

Braten, I., & Stromso, H. (2005). The relationship between epistemological beliefs, implicit theories of intelligence, and self-regulated learning among Norwegian postsecondary students. *British Journal of Educational Psychology*, 75(4), 539–565.

Braten, I., Stromso, H., & Samuelstuen, M. (2005). The relationship between internet-specific epistemological beliefs and learning within internet technologies. *Journal of Educational Computing Research*, 33(2), 141–171.

Buehl, M. M. & Alexander, P. A. (2004, July). *Motivation and performance differences among domain-specific epistemological belief clusters*. Paper presented at the annual meeting of the American Psychological Association, Honolulu, HI.

Buehl, M., & Alexander, P. (2005). Motivation and performance differences in students' domain-specific epistemological belief profiles. *American Educational Research Journal*, 42(4), 697–726.

Buehl, M. M., Alexander, P. A., & Murphy, P. K. (2002). Beliefs about schooled knowledge: Domain general or domain specific? *Contemporary Educational Psychology*, 27, 415–449.

Burns, C., & Bond, L. (2004). The relationship between mothers' beliefs about knowledge and their experiences in parent education. *Journal of Primary Prevention*, 25(4), 417–439.

Byrne, B. M. (1994). *Structural equation modeling with EQS and EQS/Windows*. Thousand Oaks, CA: Sage Publications.

Cano, F. (2005). Epistemological beliefs and approaches to learning: Their change through secondary school and their influence on academic performance. *British Journal of Educational Psychology*, 75(2), 203–221.

Cano, F., & Cardelle-Elawar, M. (2004). An integrated analysis of secondary school students' conceptions and beliefs about learning. *European Journal of Psychology of Education*, 19(2), 167–187.

Chan, K., & Elliott, R. (2000). Exploratory study of epistemological beliefs of Hong Kong teacher education students: Resolving conceptual and empirical issues. *Asia-Pacific Journal of Teacher Education*, 28(3), 225–234.

Chan, K., & Elliott, R. G. (2002). Exploratory study of Hong Kong teacher education students' epistemological beliefs: Cultural perspectives and implications on beliefs research. *Contemporary Educational Psychology*, 27, 392–414.

Chan, K., & Elliott, R. (2004). Epistemological beliefs across cultures: Critique and analysis of beliefs structure studies. *Educational Psychology*, 24(2), 123–142.

Clarebout, G., & Elen, J. (2001). The ParlEuNet-project: Problems with the validation of socio-constructivist design principles in ecological settings. *Computers in Human Behavior*, 17, 453–464.

Clarebout, G., Elen, J., Luyten, L., & Bamps, H. (2001). Assessing epistemological beliefs: Schommer's questionnaire revisited. *Educational Research and Evaluation*, 7, 53–77.

Cole, R. P., Goetz, E. T., &Willson, V. (2000). Epistemological beliefs of underprepared college students. *Journal of College Reading and Learning*, 31(1), 60–72.

Conley, A., Pintrich, P., Vekiri, I., & Harrison, D. (2004). Changes in epistemological beliefs in elementary science students. *Contemporary Educational Psychology*, 29(2), 186–204.

Duell, O. K., & Schommer-Aikins, M. (2001). Measures of people's beliefs about knowledge and learning. *Educational Psychology Review*, 13, 419–449.

Dunteman, G. H. (1989). *Principal components analysis*. (Sage University Paper series on Quantitative Applications in the Social Science, No. 07-069). Newbury Park, CA: Sage.

Elder, A. (2002). Characterizing fifth grade students' epistemological beliefs in science. In B. K. Hofer & P. R. Pintrich (Eds.), *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 347–364). Mahwah, NJ: Erlbaum.

Gorsuch, R. L. (1983). *Factor analysis* (2nd edition). Hillsdale, NJ: Lawrence Erlbaum.

Hofer, B. K. (1999). Instructional context in the college mathematics classroom: Epistemological beliefs and student motivation. *Journal of Staff, Program, and Organization Development*, 16, 73–82.

Hofer, B. K. (2000). Dimensionality and disciplinary differences in personal epistemology. *Contemporary Educational Psychology*, 25, 378–405.

Hofer, B. K., & Pintrich, P. R. (1997). The development of epistemological theories: Beliefs about knowledge and knowing and their relation to learning. *Review of Educational Research*, 67, 88–140.

Hofstede, G. (1986). Cultural differences in teaching and learning. *International Journal of Intercultural Relations*, 10, 301–320.

Jehng, J. J., Johnson, S. D., & Anderson, R. C. (1993). Schooling and students' epistemological beliefs about learning. *Contemporary Educational Psychology*, 18, 23–35.

Kang, N., & Wallace, C. (2005). Secondary science teachers' use of laboratory activities: Linking epistemological beliefs, goals, and practices. *Science Education*, 89(1), 140–165.

Karabenick, S., & Moosa, S. (2005). Culture and personal epistemology: U.S. and Middle Eastern students' beliefs about scientific knowledge and knowing. *Social Psychology of Education*, 8(4), 375–393.

Kardash, C. A. M., & Scholes, R. J. (1996). Effects of preexisting beliefs, epistemological beliefs, and need for cognition on interpretation of controversial issues. *Journal of Educational Psychology*, 88, 260–271.

Kardash, C. M., & Howell, K. L. (2000). Effects of epistemological beliefs and topic-specific beliefs on undergraduates' cognitive and strategic processing of dual-positional text. *Journal Educational Psychology*, 92(2), 524–535.

Kim, J. O., & Mueller, C. W. (1978). *Factor analysis: Statistical methods and practical issues*. (Sage University Paper series on Quantitative Applications in the Social Science, No. 07-014). Newbury Park, CA: Sage.

King, P. M., & Kitchener, K. S. (1994). *Developing reflective judgment: Understanding and promoting intellectual growth and critical thinking in adolescents and adults*. San Francisco, CA: Jossey-Bass.

Kuhn, D. (1991). *The skill of argument*. Cambridge, England: Cambridge University Press.

Lampert, M. (1990). When the problem is not the question and the solution is not the answer: Mathematical knowing and teaching. *American Educational Research Journal*, 27(1), 29–63.

Lin, C. H. (2002). Effects of computer graphics types and epistemological beliefs on students' learning of mathematical concepts. *Journal of Educational Computing Research*, 27, 265–274.

Loehlin, J. (1998). *Latent variable models: An introduction to factor, path, and structural analysis* (3rd edition). Lawrence Erlbaum.

Marra, R. (2005). Teacher beliefs: The impact of the design of constructivist learning environments on instructor epistemologies. *Learning Environments Research*, 8(2), 135–155.

Mason, L. (2000). Role of anomalous data and epistemological beliefs in middle school students' theory change about two controversial topics. *European Journal of Psychology of Education*, 15, 329–346.

McDevitt, T., Sheehan, E., Cooney, J., & Smith, H. (1994). Conceptions of listening, learning processes, and epistemologies held by American, Irish, and Australian university students. *Learning and Individual Differences*, 6(2), 231–256.

Mertens, D. M. (1998). *Research methods in education and psychology:Integrating diversity with quantitative & qualitative approaches*. Thousand Oaks, CA: Sage Publications.

Mori, Y. (1999). Epistemological beliefs and language learning beliefs: What do language learners believe about their learning? *Language Learning*, 49(3), 377–415.

Neber, H., & Schommer-Aikins, M. (2002). Self-regulated science learning with highly gifted students" the role of cognitive, motivational, epistemological, and environmental variables. *High Ability Studies*, 13(1), 59–74.

Nussbaum, E., & Bendixen, L. (2003). Approaching and avoiding arguments: The role of epistemological beliefs, need for cognition, and extraverted personality traits. *Contemporary Educational Psychology*, 28(4), 573–595.

Pajares, F. (1992). Teachers' beliefs and educational research: Cleaning up a messy construct. *Review of Educational Research*, 62, 307–332.

Paulsen, M. B., & Feldman, K. A. (1999). Epistemological beliefs and self-regulated learning. *Journal of Staff, Program, & Organizational Development*, 16(2), 83–91.

Perry, W. G. (1970). *Forms of intellectual and ethical development in the college years: A scheme*. New York: Holt (Rinehart, & Winston).

Qian, G., & Alvermann, D. (1995). Role of epistemological beliefs and learned helplessness in secondary school students' learning science concepts from text. *Journal of Educational Psychology*, 87, 282–292.

Qian, G., & Pan, J. (2002). A comparison of epistemological beliefs and learning from science text between American and Chinese high school students. In B. K. Hofer & P. R. Pintrich (Eds.), *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 365–386). Mahwah, NJ: Erlbaum.

Ryan, M. (1984). Monitoring text comprehension: Individual differences in epistemological standards. *Journal of Educational Psychology*, 76(2), 248–258.

Schoenfeld, A. (1992). Learning to think mathematically: Problem-solving, metacognition, and sense making in mathematics. In D. A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 334–370). New York: Macmillan.

Schommer, M. (1990). Effects of beliefs about the nature of knowledge on comprehension. *Journal of Educational Psychology*, 82, 498–504.

Schommer, M. (1993). Epistemological development and academic performance among secondary students. *Journal of Educational Psychology*, 82, 498–504.

Schommer, M. (1994). Synthesizing epistemological belief research: Tentative understandings and provocative confusions. *Educational Psychology Review,* 6, 293–319.

Schommer, M. (1995). *Epistemological belief questionnaire for middle school students*. Unpublished manuscript.

Schommer, M. (1998). The role of adults' beliefs about knowledge in school, work, and everyday life. In M. C. Smith & T. Pourchot (Eds.), *Adult learning and development* (pp. 127–143). Mahwah, NJ: Lawrence Erlbaum.

Schommer, M., & Dunnell., P. A. (1992, April). *Epistemological beliefs among gifted and non-gifted students*. Paper presented at the annual meeting of the American Educational Research Association, San Francisco, CA.

Schommer, M., & Dunnell, P. A. (1994). A comparison of epistemological beliefs between gifted and non-gifted high school students. *Roeper Press*, 16, 207–210.

Schommer, M., Crouse, A., & Rhodes, N. (1992). Epistemological beliefs and math text comprehension: Believing it is simple does not make it so. *Journal of Educational Psychology*, 84, 435–443.

Schommer-Aikins, M. (2004). Explaining the epistemological belief system: Introducing the embedded systemic model and coordinated research approach. *Educational Psychologist*, 39(1), 19–29.

Schommer-Aikins, M., Duell, O., & Hutter, R. (2005). Epistemological beliefs, mathematical problem-solving beliefs, and academic performance of middle school students. *Elementary School Journal*, 105(3), 289–304.

Schommer-Aikins, M., Mau, W., Brookhart, S., & Hutter, R. (2000). Understanding middle students' beliefs about knowledge and learning using a multidimensional paradigm. *Journal of Educational Research*, 94, 120–128.

Schraw, G., Bendixen, L. D., & Dunkle, M. E. (2002). Development and validation of the Epistemic Belief Inventory (EBI). In B. K. Hofer & P. R. Pintrich (Eds.), *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 261–275). Mahwah, NJ: Erlbaum.

Schraw, G., Dunkle, M. E., & Bendixen, L. D. (1995). Cognitive processes in well-defined and ill-defined problem solving. *Applied Cognitive Psychology*, 9, 523–538.

Sinatra, G., & Kardash, C. (2004). Teacher candidates' epistemological beliefs, dispositions, and views on teaching as persuasion. *Contemporary Educational Psychology*, 29(4), 483–498.

Spiro, R. J. (1989). *Epistemological beliefs questionnaire*. University of Illinois, Center for the Study of Reading, Champaign, IL. [Unpublished raw data].

Thompson, B. (1997). The importance of structure coefficients in structural equation modeling confirmatory factor analysis. *Educational and Psychological Measurement*, 57(1), 5–19.

Thompson, B., & Daniel, L. (1996). Factor analytic evidence for the construct validity of scores: A historical overview and some guidelines. *Educational and Psychological Measurement*, 56(2), 197–208.

Wood, P., & Kardash, C. (2002). Critical elements in the design and analysis of studies of epistemology. In B. K. Hofer & P. R. Pintrich (Eds.), *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 231–260). Mahwah, NJ: Erlbaum.

Youn, I. (2000). The culture specificity of epistemological beliefs about learning. *Asian Journal of Social Psychology*, 3, 87–105.

Youn, I., Yang, K., & Choi, I. (2001). An analysis of the nature of epistemological beliefs: Investigating factors affecting the epistemological development of South Korean high school students. *Asia Pacific Education Review*, 2(1), 10–21.

Zwick, W., & Velicer, W. (1986). Comparison of five rules for determining the number of components to retain. *Psychological Bulletin*, 99(3), 432–442.

Chapter 5
Measurement of Epistemological Beliefs and Learning Strategies of Elementary School Children

Barbara Moschner, Andrea Anschuetz, Stephan Wernke, and Uta Wagener

Abstract Research about epistemological beliefs and learning strategies is a steadily growing area in educational psychology and in the field of education. Subjects in most of the published studies are adults or teenagers, only a few studies deal with children or even elementary school children. Some experts doubt if children have epistemological beliefs, others question if they have the competence to talk about abstract concepts like beliefs about knowledge and knowing or learning strategies. In addition measurement issues are far from being resolved.

In this chapter we first give a short overview of existing studies about epistemological beliefs and learning strategies in elementary school children. We look at the connection between epistemological beliefs and learning strategies and propose that epistemological beliefs and learning strategies are closely related.

In another step we review methodological issues. What are the advantages and the disadvantages of the used measurements? Merits and shortcomings are discussed. We show that research on epistemological beliefs of children may benefit from the methodological discussion in the field of learning strategies and self-regulated learning. We address developmental prerequisites and methodological problems concerning research in this age group. Finally, we discuss the relevance of different measurements for future research with young children.

5.1 Measurement of Epistemological Beliefs

Interviews and questionnaire measures are the most widespread methods to get information about epistemological beliefs of individuals. Looking back at early investigations, it is obvious, that a combination of both methods was quite popular from the very beginning of research in this field.

Carl von Ossietzky Universität Oldenburg, Oldenburg, Germany

M. S. Khine (ed.), *Knowing, Knowledge and Beliefs: Epistemological Studies across Diverse Cultures.*

5.1.1 Measurement of Epistemological Beliefs of Students and Adults

Most articles about epistemological beliefs start with a short summary of Perry's (1970) work about the intellectual and ethical development of students in their college years. Perry used two methods to explore the cognitive development of Harvard undergraduate students. He conducted open-ended interviews asking them to describe outstanding experiences and transformations during their college years. Perry also developed and administered a questionnaire named CLEV (Checklist of Educational Values).

In the following sections we give an overview about interview questions, we show examples of questionnaire items and we review studies using dilemmas, scenarios, and ill-structured problems. We also discuss chances and problems of multi-method designs.

5.1.1.1 Interviews

As mentioned above, Perry (1970) conducted the first well-known interview study in the field of epistemological beliefs. His interviews were open-ended, only partially structured, and questions were rather broad (e.g., "Would you like to say what has stood out for you during the year?"). Although he was looking for personality differences of college students, analysing the interview data of (mostly) male college students he came out with a cognitive model of development of epistemological beliefs during college years. He postulated a scheme of intellectual and ethical development that describes how college students make meaning of their educational experience.

Following Perry's (1970) line of research but criticising him for concentrating on male students, some researchers were interested in gender-related issues of epistemological beliefs. Belenky et al. (1986) used semi-structured interviews to measure female's epistemological beliefs. They started the interviews with a similar question as Perry ("What stands out for you and your life over the last few years?") and included questions about gender, relationship, education, and ways of knowing. Based on their data, the authors proposed a model of different epistemological perspectives from which women view the world.

Baxter Magolda (1992) was the first researcher who included female and male subjects equally in her study. Although she started with the development of a new questionnaire MER (Measure of Epistemological Reflection, see section 5.1.1.2) she also conducted a longitudinal interview study. In her open-ended interviews she covered six topics: the roles of learners, instructors and peers, the nature of knowledge, the evaluation in learning, and decision-making. As an introductory question for each topic, she started with questions like "Have you ever encountered a situation in which you heard two explanations for the same idea?" (Baxter Magolda, 2002). Follow-up questions were used to clarify students' responses.

Baxter Magolda also categorised the data and developed her own model. According to her results, ways of knowing were not segregated by gender, but she found gender-related reasoning patterns within three of her categories.

5.1.1.2 Questionnaires

Already in the mid-1950s, Perry (1970) developed and administered his questionnaire named CLEV (Checklist of Educational Values). Some items of this questionnaire are still included in current instruments (e.g., "The best thing about science courses is that most problems have only one right answer"). Obviously, Perry concentrated his work more on the interview data than on the questionnaire data. His developmental model is exclusively based on his interview material.

Baxter Magolda (1992) developed another questionnaire named MER (Measure of Epistemological Reflection) that contained a number of open-ended questions like "Some different instructors give different explanations for historical events or scientific phenomena" or "When two instructors explain the same thing differently can one be more correct than the other?". Like Perry, Baxter Magolda based her Epistemological Reflection Model on her interview data and not on her questionnaire data.

The most well-known questionnaire in the field might be Schommer's (1990) Epistemological Questionnaire. It was conceptualised to measure five independent dimensions of epistemological beliefs: beliefs about the stability of knowledge, the structure of knowledge, the source of knowledge, the speed of knowledge acquisition, and the control of knowledge acquisition. Even though this questionnaire has been administered in many studies, reliability of the sub-scales tends to be low. Clarebout et al. (2001) used a translated version of Schommers questionnaire in two empirical studies. In neither of these two studies the factor structure of Schommer (1990) could be replicated. In addition, in both studies a different factor structure was found. The authors also failed in their attempt to construct reliable scales based on the items of the questionnaire: "all scales contain only a limited number of items and are not very reliable" (p. 53). Based on a review of the literature and on their own data, Clarebout et al. (2001) do not recommend to use the Epistemological Questionnaire any longer. Nevertheless researchers all over the world still tried to use this instrument and to replicate the factorial structure.

Several other questionnaires to assess epistemological beliefs have been published (e.g., Schraw et al., 2002; Conley et al., 2004), but none of them became as popular as Schommer's instrument.

5.1.1.3 Think-aloud Protocols

Hofer (2004a) investigated students online searching for a simulated science assignment through the use of think-aloud protocols in a set of studies. Using this method, she examined students' personal epistemology not as a decontextualised set of beliefs but as a situated aspect of cognition which helps to understand the knowledge construction process. Her results show that students made epistemic judgements and monitored the epistemological nature of their learning. Four dimensions of epistemic theories were found in the think-aloud protocols. Individual expertise in a field was more related to prior knowledge and to course-taking than to age or year in school. Students' expertise was domain specific, they hardly transferred their expertise to other disciplines.

5.1.1.4 Ill-structured Problems and Dilemmas

King and Kitchener (1994) were interested in epistemic assumptions that underlie reasoning. In their studies subjects had to deal with four ill-structured problems (how the pyramids were build, safety of chemical additives in food, objectivity of news, issues of creation and evolution). Subjects were asked to state and justify their perspectives on the problems and had to answer questions dealing with their assumptions about knowledge and knowledge acquisition (e.g., "Can you ever know for sure that your position on this issue is correct?"; King & Kitchener, 2002, p. 39). Analysing their data, King and Kitchener proposed a developmental model of reflected thinking which elaborates the upper stages of Perry's original model.

Kuhn (1991) used a similar method. Her subjects also had to deal with ill-structured problems. They were asked questions like: "What causes prisoners to return to crime after they're released?" and "What causes children to fail in school?" Interviewees were demanded to reflect on their reasoning (e.g., how sure they are about their own viewpoint, if others could come to another conclusion, if there could be a proof of their arguments). The answers of the interviewees were classified into three categories (absolutists, multiplists, and evaluativists) which represent a short version of Perry's (1970) scheme.

5.1.1.5 Multi-method Designs

Looking at the historical roots of research on epistemological beliefs, most researchers already used multi-method designs (mostly interviews combined with questionnaires). However, some of them seemed to have ignored their questionnaire data and built their models upon the results of their interview studies. One of the reasons for this might be the lack of valid and reliable questionnaire instruments in this area. Pintrich (2002) concludes: "Personal epistemologies can and should be assessed using a diversity of methodologies" (p. 411). Such research designs can provide data on the validity and reliability of measures.

One of the few studies with a true multi-method design was conducted by Hofer (2004b). She combined classroom observations and interviews of 25 first year students to attain a contextualised perspective on the dimensionality of epistemological beliefs. The study provides evidence for four dimensions of epistemological theories.

5.1.2 Studies and Measurement of Epistemological Beliefs of Children

Although there is a tremendously growing number of investigations in the field of epistemological beliefs, only a few studies examine elementary school children. To show how epistemological beliefs in children can be measured we shortly review some existing studies.

5.1.2.1 Interviews

Haerle (2006) focused in his study on beliefs of German fourth graders about the origin of knowledge, the acquisition of knowledge, and the verification of knowledge. He conducted semi-structured interviews with 98 children aged 9–12 years. During the interview he created a concept map of each child's personal epistemologies which was validated in direct communication with the child. One of the main findings of the study is that all children were able to verbalise their epistemological beliefs. A variety of epistemological beliefs was revealed: different beliefs about the origin of knowledge were mentioned (e.g., human invention, biological inheritance, given by God, result of trial and error). Children identified various ways for the acquisition of knowledge (e.g., sensory perception, logical thought, personal experiences). They also mentioned different strategies to verify knowledge (e.g., investigations, logical thought, personal experience, asking, looking it up, comparing different resources).

5.1.2.2 Questionnaires

Elder (2002) investigated epistemological beliefs in the area of science of 211 fifth-grade students with a questionnaire. The first part of this instrument consists of three open-ended items concerning questions about the definition of science and the sources for their own ideas about science and the sources of scientists' ideas of science. In the second part the children were asked to answer 25 items on a 5-point Likert-scale that include statements about the changing nature of science, the role of experiments, the coherence of knowledge, and the source of knowledge. He observed that elementary school children's individual epistemological beliefs in science are a mixture of naïve and sophisticated understandings. Even fifth-grade students tended to evaluate scientific knowledge as a changing and developing construct generated by testing and reasoning. On the other hand children showed little understanding for the characteristic effort in science to explain a phenomenon. The main purpose of science is seen as an engagement in activities like conducting projects and observations. Elementary school children predominantly mentioned active endeavours for example thinking and wondering as sources of scientists' ideas. In contrast, they named more passive endeavours as sources for their own scientific ideas (e.g., getting ideas from books, television, or other people).

Conley et al. (2004) conducted a questionnaire study with 187 fifth-grade students. The students were asked to answer questions before and after a nine-week science unit. The instrument contained 26 items concerning four dimensions of epistemological beliefs: source, certainty, development, and justification of knowledge. Children were asked to answer the items on a 5-point Likert-scale with a focus on the domain of science. The results show that some dimensions of epistemological beliefs of young children do change over time. Elementary school children became more sophisticated in their beliefs about the source and the certainty of knowledge over the nine weeks of investigation. There were no significant changes in the dimensions development and justification of knowledge.

5.1.2.3 Scenarios and Dilemmas

Kuhn et al. (2000) compared the epistemological understandings of children, adolescents, and adults of seven age groups. They focused on subjective and objective dimensions of knowledge. Children in the two youngest age groups were 10- and 13-years old. All participants had to read contrasting statements. In these statements two individuals named Robin and Chris presented their incompatible opinions. Subjects had to write down for every single item if only one statement was right or if even both statements could be right. If they answered that both opinions could be right, they were additionally asked if one judgement could be better or more right than the other. One result of the study was that even some 10-year-old children show an evaluatistic level of epistemological understanding. Moreover the results show that subjectivity is most readily accepted in domains concerning personal taste and aesthetic judgements.

In a longitudinal study Mansfield and Clinchy (2002) investigated the development of epistemological beliefs in children at the ages 10, 13, and 16. Like Kuhn et al. (2000) they focused on the objectivity and subjectivity of knowledge. Scenarios in which two persons disagreed about different issues were presented at the beginning of an interview. Those scenarios contained issues ranging from more solvable questions of fact to more unsolvable questions of taste and value. After the presentation of the scenarios the children were asked why the two persons disagreed, which person is right and whether and how the conflict is resolvable. Results showed that even 10-year-old children could articulate the underlying epistemological rules they used to analyse the scenarios. Furthermore, Mansfield and Clinchy (2002) demonstrated that children's awareness of the complexity of "objective reality" and "internal subjective knowledge" increased with their age. Additionally, children became more constructive and less reactive in their line of argumentation. Another important finding is that children achieved the highest epistemological sophistication when issues were closest to their everyday experiences (Mansfield & Clinchy, 2002).

5.2 Measurement of Learning Strategies and Self-regulated Learning

Self-regulated learning is viewed as a multi-component process that involves motivation, goal setting, strategic action (learning strategies), and metacognitive monitoring of the course and the outcomes of learning. It is described as a way of learning that will not only impart knowledge but also promote the ability for future learning and lifelong learning at the same time. Learning is thereby conceptualised as active and constructive (Pintrich, 2000; Zimmermann & Schunk, 2001).

Existing measurements of self-regulated learning include questionnaires, structured interviews, stimulated recall interviews, teacher ratings, think-aloud protocols, observation, trace methodologies, error detection tasks, and situational manipulations (Winne & Perry, 2000; Boekaerts & Corno, 2005).

Reviewing research in learning strategies and self-regulated learning shows that most of the existing studies concentrate on older children and college students. But in recent years there has been evidence that already young children are able to regulate their learning under certain conditions. There is a growing interest in self-regulated learning of children, its processes, individual and contextual conditions, and outcomes (Winne & Perry, 2000).

5.2.1 Questionnaires

Concerning the measurement of learning strategies and self-regulated learning self-report questionnaires are the most frequently used instruments. The two predominating measures in Anglo-American studies are the Learning and Study Strategies Inventory (LASSI; Weinstein, 1988) and the Motivated Strategies for Learning Questionnaire (MSLQ; Pintrich et al., 1993). In Germany the most dispersed questionnaire is an instrument named "LIST" (Lernstrategien im Studium; Wild & Schiefele, 1994). This questionnaire is a German adaptation of the MSLQ.

The LASSI includes the scales anxiety, attitude, concentration, information processing, motivation, time management techniques, selecting main ideas, self-testing, study aids, and test strategies. On the other hand the MSLQ includes two main sections: motivation on the one hand and learning strategies on the other. The motivational scales deal with students' goals, self-efficacy, and their test anxiety. The learning strategies scales are divided into three categories: use of metacognitive and cognitive strategies and management of different learning resources. The same scales are included in the LIST.

To answer such self-report questionnaires the respondents have to decide how much they agree or disagree with statements describing their habitual learning process. Subjects have to estimate for example how often they act in the following way: “When I study I put important ideas into my own words” or “I ask myself questions to make sure I know the material I have been studying” (MSLQ; Pintrich et al., 1993). The interviewees are supposed to reflect their own learning process, to give information about their habitual use of cognitive and metacognitive strategies, and to judge their resource management.

These instruments, their scales and sub-scales were verified in several studies and distinguished by high reliability. But against all expectations significant correlations between the use of learning strategies (measured by these questionnaires) and achievement were only occasionally shown. A study with the questionnaire “WLI” (Wie lerne ich – how I learn; Lompscher 1995b) investigating fourth-, sixth-, and eighth-grade students showed the possibility to ask elementary school children to answer to self-report questionnaires. The children were able to verbalise their thinking and processing. But this study could not show correlations between the use of strategies and learning outcomes.

Current questionnaires inquire learning strategies in concrete learning scenarios. Leopold and Leutner (2002) presented students of different age groups short scientific scripts, for example, about bats and how they orientate. The students were prompted to read the text and to answer a questionnaire about the strategies they have used reading it. Thereto items like “Did you imagine how the bats orientate with the help of sound waves?” were used, or students had to sketch a little picture of a flying bat. Later the students had to answer a comprehensive test. Measuring the use of strategies in concrete learning situations and paying attention to quality of students’ answers, resulted in higher correlations between reported strategies and learning success.

5.2.2 Interviews

In interviews subjects are asked to verbalise how they think and act in specific learning situations. Subjects’ given information is either retrospective, if they are asked to verbalise cognitive and metacognitive activities in former learning situations. Or the information is prospective, if persons are asked which strategies they would use in exemplary learning situations in the future. Interviews can be highly structured with structured scripts, questions, and follow-up questions but it also can be composed of one or more open questions like “Tell me about how you…”.

One of the most popular interviews measuring learning strategies is the Self-Regulated Interview-Schedule (SRLIS; Zimmerman & Martinez-Pons, 1986). At the beginning of this interview specific learning situations are presented, for example, doing homework or preparing for tests. After that the students are asked to give detailed information about how they would act in these situations. In order to quantify the mentioned strategies the interviewees are asked to rate how often they use them. Afterwards the detected strategies are allocated to cognitive strategies, metacognitive strategies, or strategies of resource management. Using the SRLIS

Zimmerman and Martinez-Pons (1986) found significant correlations between learning strategies (including all strategy scales) and learning achievement in English (r = 0.56) and mathematics (r = 0.55).

Purdie et al. (1996) investigated Japanese and Australian 10th–12th-grade students with the SRLIS in order to compare students intercultural learning habits. In contrast to Zimmerman and Martinez-Pons (1986) they used the SRLIS in a written form. Their study examined differences between students' conceptions of learning and their use of strategies. Japanese students view learning from a much broader perspective than Australian students. For them, learning is not only related to school, moreover it is a lifelong process leading to personal fulfilment. Despite this difference, overall, the strategies used by Australian students are similar to those used by Japanese students. Distinct differences were only found in the use of the strategy support through teachers. Japanese students reported distinctly less use of this strategy than Australian students.

5.2.3 Think-aloud Protocols

Another possibility to examine self-regulated learning are think-aloud protocols. The aim of this method is to measure cognitive and metacognitive strategies directly in the learning process. Students are prompted to report their thoughts and cognitive processes while performing a task. They have to give explicit information about what they are doing and have to comment their strategic acting. In order to prevent interferences between the learning action and the verbalisation, the learning actions are stopped for short times (Garner, 1988).

Using think-aloud measures Hayes and Flower (1980) compared first semester college students and their teachers. Both were prompted to verbalise their acting while writing an article. Differences were found in the planning of their activities. Contrary to the beginners the experts worked more organised and had less problems to formulate goals. Furthermore the experts talked more about monitoring their writing process.

Similar results were found by Zwaan and Brown (1996). They collected verbal protocols from skilled and less-skilled readers as they comprehend a story. The inventory showed differences between the two groups in the extent to which they made certain classes of inferences. For example, skilled readers reported more explanatory inferences than less-skilled readers.

5.2.4 Stimulated Recall

Stimulated recall is a method that can be seen as an attempt to solve problems of think-aloud protocols. After videotaping a learning sequence students watch the recording. They are asked to verbalise their thoughts and actions in the shown situations. Stimulated recall interviews are intended to measure self-regulated learning in the learning process, but in contrast to think-aloud protocols this method does not interrupt or disturb the learning process. The method has the advantage that the videotaped material helps the students to reflect their own doing.

Peterson et al. (1982) videotaped fifth- and sixth-grade students during two lessons, showed the tape to the students after each lesson and asked them to comment their actions and thoughts in the recorded situation. Statements were classified as metacognitive processes like anticipation, monitoring understanding, checking, and asking for help. In addition the students answered a questionnaire concerning metacognitive strategies after the second lesson. Comparing the results of both measures only low, insignificant correlations were found.

5.2.5 Observations

Observation is a method used to measure mainly behavioural aspects of self-regulated learning and the use of learning strategies in naturalistic settings. Even if the focus of observation is on behaviour, cognitive and metacognitive aspects come into view as well. All the reviewed observational studies used observation in a multi-method design that included other means of collecting data like interviews and questionnaires.

Observation methods are often used in classroom studies. Different content aspects can be focused within the classroom. The observation can concentrate on teacher behaviour, student behaviour, peer interaction, teacher–student interaction, and more specific aspects like for example, the use of academic help seeking or volitional strategies. According to this centre of interest the observational method can be varied.

One aspect is the manner in which the observation is recorded. Some researchers use technical support like audio (Corno, 2001) or video recording (Veermans & Järvelä, 2004). Aided by audio or video recording observation enables the discourse analysis of peer interaction and classroom instruction. This provides an insight in the process of scaffolding and in social and collaborative aspects of self-regulated learning (Meyer & Turner, 2002; Patrick & Middleton, 2002; Perry et al., 2002). Another possibility is the use of running records or systems of predefined categories that are rated by one or more researchers directly in the observed situation (Perry, 1998; Turner, 1995).

Another differentiation has to be made between studies that alter classroom conditions according to the focus of interest and others that do not systematically intervene in classroom or task conditions. In some studies specific task variables are being controlled in otherwise regular classroom settings (Corno, 2001). Other studies do not change classroom conditions but analyse the naturalistic context as one part of the research (Perry, 1998). Training studies sometimes use observation of behaviour in addition to other methods. These studies make numerous changes in classroom conditions and normally use a control group to analyse the effects that are caused by these modifications.

Corno (2001) reports an observational classroom study on volitional strategies used by fifth-graders. To make sure they would be able to observe the use of volitional strategies the researchers varied task structures in a way that induced volition: students had to work collaboratively on a task that was required by the teacher, the task had to be completed in a certain time limit, and was of moderately low difficulty. Their verbal behaviour during task completion was recorded, transcribed, and analysed.

5.2.6 Field Studies

In a line of research which is predominant in educational psychology applied studies are in the focus of interest: children's self-regulated learning in classrooms is examined (Perry, 1998; Veermans, 2004). Other studies concentrate on ways to promote self-regulated learning in this age group (Perry, 2002; Harris et al., 2006; Turner, 1995).

In the tradition of applied studies there is today a concern to use measurements that are able to integrate aspects of the subject, the social context, and the learning environment in the analysis. This is closely related to the use of qualitative measures such as observation and interviews to "uncover the interplay between the social and individual processes that shape self-regulated learning in context and on-line" (Butler, 2002, p. 61).

Perry (1998) examined young children's self-regulated learning in a writing curriculum under different contextual conditions. Examining children in second and third grade of elementary school she combined measurements such as questionnaires, observation, and interviews. Observing classrooms, Perry rated task structures and teacher–student interaction according to predefined categories as high self-regulated learning or low self-regulated learning environment. Children in the high self-regulated learning classrooms planned and drafted more often what they wanted to write, monitored, and evaluated their work and sought for instrumental support if necessary. Accordingly they were less likely to use self-handicapping, defensive strategies when facing difficulties. Consistent with this study the classroom context can be seen as an important factor in the development and performance of self-regulated learning.

5.2.7 Diaries

Another way to measure self-regulated learning which should be mentioned is to prompt students to comment their learning process in diaries. In order to get information about their cognitive and metacognitive strategies, their motivation, volition strategies, and their emotions, they have to describe their acting and feeling, for example, while doing homework. Those diaries can consist of structured items like questionnaires as well as open questions like in interviews.

Souvignier and Roes (2005) compared in a study with German 11th-grade students questionnaire data with diary data. Both instruments showed good α-values and both could show correlations between the use of strategies and learning achievement but no correlations between questionnaire data and diary data were found.

5.2.8 Multi-method Designs

Spoerer (2004) developed a German adaptation of the SRLIS and compared it with a questionnaire based on the MSLQ. The aim of her study was to answer if students' statements in structured interviews correspond with their answers given in a learning strategy questionnaire. Spoerer examined eighth-grade students in a longitudinal study over one year. The results indicated that strategies students reported in the interview were nearly 0-correlated with their answers in the questionnaire. Multiple regression analyses showed that questionnaire scores did not predict changes in grades and achievement test but learning strategies assessed with the interview did.

Patrick and Middleton (2002) described the combination of video-observation, interviews, and questionnaires in a study about self-regulated learning of seventh- and eighth-grade urban students who are taking part in a project-based science curriculum. From each class four or five target students were chosen and examined closely with a combination of qualitative and quantitative measures. In the video-observation a target student and his or her group was focused. Classes were videotaped about three times per week during the whole curriculum. At the end of the curriculum target students were interviewed concerning their engagement, motivation, collaboration, and technology use. Questionnaires about cognitive and metacognitive strategies, motivation, and perceived collaborative support were administered to all students. In the analysis, outcomes of different measurements were compared for each target student. Results of observation and self-report were not always consistent, also the results of interviews and observation showed some differences. This multi-method design reveals different patterns in motivational orientation and strategy use. It may prompt researchers to discuss the value and validity of different measurements. One issue that Patrick and Middleton underline is that "we need to consider what students and researchers mean by the words that are used" (Patrick & Middleton, 2002, p. 36).

5.3 Studies About Learning Strategies and Epistemological Beliefs

It is assumed that epistemological beliefs and learning strategies are closely linked (Pintrich, 2002) but studies addressing the interrelation between epistemological beliefs and learning strategies are rare.

In an investigation Schommer et al. (1992) gathered data about epistemological beliefs and learning strategies of 138 college students with questionnaires. After reading a statistical passage participants had to rate their confidence in their text comprehension and completed a test. The epistemological dimension simple knowledge had direct as well as indirect effects on learning outcomes. Students who scored low on simple knowledge performed better in the mastery test and assessed their comprehension more accurately than students who scored high on simple knowledge. The authors also found indirect effects of the dimension simple knowledge on learning outcomes mediated by learning strategies: students who believed that knowledge consists of isolated facts tended to learn by heart without reflecting and elaborating. Little effort was made to interrelate facts. This kind of test preparation correlated negatively with test performance. On the other hand the less students believed in simple knowledge, the more they reported the use of deep-processing learning strategies (Schommer et al., 1992).

Schommer (1994) summarised her text comprehension studies that show direct and indirect effects of epistemological beliefs on learning performance. Indirect effects of epistemological beliefs on learning outcomes are mediated by learning strategies. The more the students believe in simple knowledge, the more they use surface learning strategies and learn by heart. In addition, Schommer-Aikins (2002) interpreted direct effects of epistemological beliefs on learning outcomes as filters in the reading and interpretation of texts (Schommer-Aikins, 2002).

5.4 Methodological Challenges in the Assessment of Epistemological Beliefs and Learning Strategies in Children

Although studies have shown that it is possible to assess epistemological beliefs and learning strategies in elementary school children, some unresolved methodological questions remain. Every single method has advantages and disadvantages which will be discussed in the following section. To overcome the methodological shortcomings multi-method designs might be helpful.

5.4.1 Questionnaires

Advantages of questionnaires are quite obvious. They are easy to administer to large groups and they are easy to analyse. But if even adults have sometimes problems to abstract their thinking, it is an even bigger problem for children. Do children have the ability to give abstract information about their beliefs and about their learning process? One of the implicit assumptions of questionnaire studies is that the subjects of the study are able to understand the items in the intended way. This understanding is limited by two aspects. The first aspect is text comprehension and the second aspect is the understanding of the meaning. These two aspects should be taken into account in every study but they are even more important for studies with young children.

Although different questionnaires for the assessment of epistemological beliefs of adults, college students, and high school students exist, their reliability and construct validity remains often questionable. Hardly any attempt has been made to develop a questionnaire instrument for younger children.

Questionnaires which were developed to measure learning strategies are more often distinguished by high reliability scores. Despite these advantages and against all expectations significant correlations between the use of learning strategies (measured by these questionnaires) and achievement were only occasionally shown. Based on a review of 21 questionnaire studies, Veenman (2005) reported that the predictive value for learning outcomes was very low (mean of explained variance <3%). As a reason for these low predictive values several measurement issues are discussed: answers to the items of these questionnaires only show the personal estimation of the habitual use of strategies. Studies have shown that subjects are usually not able to have a realistic idea of the frequency of their use of learning strategies (Spoerer & Brunstein, 2005). Respondents must be able to reflect their own learning process on a metacognitive level. Some studies show that even adults have problems to reach this level of reflection (Veenman, 2005). In addition questions may lead to social desirable answers and there are serious doubts whether skills can be assessed by questionnaires.

5.4.2 Interviews

Interviews and interview techniques are criticised partly for the same aspects as questionnaires. The data of interview measures is also based on self-reports. Respondents have to reflect metacognitively their own beliefs or their own learning process. Problems of a confoundation with verbal abilities are obvious. On the other hand using interviews, possible misunderstandings can easily be solved. Respondents and researchers can ask for details or explanations. It also should be mentioned that conducting and analysing interviews is very time consuming.

5.4.3 Think-aloud Protocols and Stimulated Recall

Pros and cons of thinking aloud protocols can be seen in the simultaneity of working and verbalising. On the one hand an insight in cognitive processes is given but on the other hand cognitive and metacognitive processes are interrupted by the demand to verbalise them (Ericsson & Simon, 1980, 1993). The procedure is very time consuming and demands awareness and good verbal abilities to talk about the own metacognitive processes. This is also true for stimulated recall measures but this method does not interfere with the learning process. Videotaped material can help the students to reflect their own doing.

Thinking aloud protocols and stimulated recall were not used in investigations of epistemological beliefs.

5.4.4 Observations

Systematical observation techniques are often used in studies with younger children who are not verbaly fluent (Veenman, 2005). Observations can only account for behavioural assessment. Metacognitive activities can be coded, metacognitive intentions directing these activities can only be assumed. In observational studies it is extremly important to have a good coding scheme and to cross-validate the results with other measures (e.g., thinking aloud protocols or stimulated recall). Furthermore, inter-rater-reliability of the coding scheme should be proved.

Three advantages of observation are discussed in the literature (Turner, 1995; Winne & Perry, 2000). First, observational data measures what learners do as opposed to what they think or recall they do. Second, observation enables to analyse the links between learner's behaviour and aspects of the context such as task structure, instructional practices, etc. Third, observation can be valuable especially in the research with young children because it allows to avoid difficulties such as positive response bias and limited language.

So far, observational methods have not been used in research about epistemological beliefs.

5.4.5 Scenarios and Dilemmas

Scenarios, dilemmas, and ill-structured problems are widely used in the research of epistemological beliefs. Especially for King and Kitchener (1993) and for Kuhn (1991) these are adequate methods to avoid general and oversimplified questions about epistemological issues. Interview questions are contextualised by this way and subjects do not need to make assumptions about examples for rather general statements. Using these methods, researchers have the chance to find out if epistemological beliefs are domain specific or context specific.

Current questionnaires of learning strategies also inquire strategies in concrete learning scenarios. Measuring the use of strategies this way resulted in higher correlations between reported strategies and learning success (Leopold & Leutner, 2002).

5.5 Developmental Issues and Cognitive Competencies of Children

Self-regulated learning and epistemological beliefs are exclusively human acquisitions (Demetriou, 2000). Their development depends on individual construction and on participation in a social culture (Kuhn, 2000). Which competencies are necessary for self-regulated learning and epistemological beliefs? At what age are these competencies developed?

Research on "theory of mind" investigates the question of when and how humans develop a concept of mental representations of oneself and others. Studies show that preschool children make a distinction between "the world of things" and "the world of thinking" and they know that thinking is different from perceiving and different from knowledge (Demetriou, 2000; Flavell et al., 1995). Nevertheless 3-year-olds still have difficulties to differentiate between beliefs (what a person thinks about something) and reality (what is the case). This changes at the age of 4–5 years when children acquire the concept of false beliefs. They begin to understand that the perspective and knowledge of someone else may differ from their own knowledge, and that beliefs may differ from reality. They also understand that this individual perspective is crucial for the thinking and behaviour of an individual. These developments can be characterised as a personal representational theory (Kuhn, 2000).

Epistemological beliefs can be characterised as a special kind of meta-knowing, a term that encompasses all cognitions on cognitions, on one's own cognitions or those of others (Kuhn, 2000). They therefore depend not only on the development of mental representations but also on the development of recursive mental representations. Within the concept of meta-knowing Kuhn distinguishes between metacognitive knowing, metastrategic knowing, and epistemic knowing. The differentiation between metacognitive and metastrategic knowing relies on the concepts of declarative and procedural knowledge. Metacognitve knowing is about declarative knowing and metastrategic knowing is about procedural knowing. Epistemological meta-knowing is the more abstract part of metacognitve knowing: knowing about knowledge and knowing in general. Kuhn describes this knowledge as central for the development of scientific and argumentative reasoning.

The acquisition of the concept of false beliefs enables children to evaluate beliefs as either false or true. This development starts at the age of 4–5. For children of this age knowledge results from having seen or experienced something. If two subjects have seen and heard the same, these children are convinced that the two persons will have the same beliefs. Knowledge is understood as subjective but nonetheless originating directly from the physical world (Kuhn, 2000). This concept can be characterised as an absolutistic epistemological belief.

The further development of more sophisticated epistemological beliefs is also related to cognitive development but depends very much on environmental influences. Some studies indicate that children as young as 7–8 have the ability to understand that two persons with the same information can come to different interpretations of one and the same thing. In other words: children at this age show a beginning objectivism-relativism transition in beliefs about the nature of knowledge (Hallet et al., 2002). This is a contradiction to the claims of other researchers who have assumed that the first change in epistemological beliefs can be observed and measured in the high school or college years (Perry, 1970; Baxter Magolda, 1992). Chandler et al. (2002) differentiate between early and late onset theories. Early onset theorists believe that already young children make advances in epistemic thinking whereas late onset theorists suggest that epistemic advancement requires a higher education. Chandler and colleagues suggest a recursive process: "much of what is imagined to be novel in adolescence or young adulthood actually represents some second, or perhaps even third, pass through 'the same' epistemic level" (p. 161).

Which competencies are necessary for self-regulated learning? Demetriou (2000) names three necessary conditions: (1) self-monitoring; (2) a self-system consisting of representations of nature, history, and preferences of the self; and (3) strategies and skills for self-modification. Self-regulation can be regarded in relation to other concepts (e.g., self-control; Kopp, 1982). Self-control is seen as a more basal function that is supposed to develop at the end of year 2. Self-regulation is seen as the more adept competence that involves reflection and use of strategies and thereby also involves consciousness, introspection, and metacognitions. Due to these reflexive elements self-regulation enables us to adopt our behaviour to varying environmental conditions. Demetriou (2000) locates the beginning of self-regulative behaviour at the age of 3–4. In further development, self-regulation progresses to systematic, long-term, or strategic self-regulation. This kind of self-regulation is supposed to start at the age of 9.

Kuhn (2000) argues that even if young children are able to act strategically but they lack metastrategic knowledge. Therefore children have shown difficulties in the systematic use of strategies in memory tasks. These difficulties can not be affected by instruction and scaffolding.

Other researchers claim that systematic strategic self-regulation might start earlier depending on an environment that promotes this development (Perry, 1998). Boekaerts and Markku (2000) argue that already young children are able to set learning goals and to act strategically and self-regulated in their pursuit, if this is recorded in naturalistic settings. Due to the design of experimental studies cognitive competencies of pre-school children have been underestimated by developmental psychologists for some time. In these experiments children's cognitive abilities seemed to be less differentiated than they proved to be in more naturalistic settings. Studies in revision of Piaget's theory have shown that cognitive achievement of children is not so much based on stage-specific cognitive structures but on design of tasks and on context. A second insight is that cognitive development can be domain specific.

5.6 Future Perspectives for Research on Epistemological Beliefs with Children

Although research about epistemological beliefs and learning strategies is a very popular topic in educational psychology and education there is still a lack of studies with elementary school children in these areas. What can we learn from the few existing studies in the field? Which methods already used to examine self-regulated learning of children might also be fruitful for the field of epistemological beliefs?

Which research designs can give us a deep insight in developmental issues during childhood in this field?

Questionnaires are one of the most popular research methods in the field of epistemological beliefs and learning strategies. Since they are easy to administer to large populations they will be one predominant method also in research with children. But scales and items that have been designed for older children and adults need to be revised and examined before being applied to younger children. The understanding of questionnaire items and underlying concepts may vary in different age groups. There are serious doubts that even adults understand some of the general and abstract items they have to deal with. Validation studies in this area are necessary. Before the administration of newly designed questionnaires to larger populations, interview studies about the understanding of the items with children in the intended age group are necessary. It is important to ensure that children's performance is supported and not hampered by the design of measurement instruments and that children are enabled to show their competencies and beliefs.

Since abstract and general questions about beliefs and behaviour are difficult to deal with (not only for children) a contextualisation of the questions has shown to be helpful. As reported, scenarios, dilemmas, or ill-structured problems can be used in questionnaire methods as well as in interview studies. Dealing with these scenarios children might clarify their beliefs or think about arguments and counter-arguments. If scenarios are used in questionnaire research think-aloud protocols can help to understand underlying assumptions behind the answers. But there are also some shortcomings of these methods. The ability to verbalise might seriously interfere with the interpretation of the data. Children who are not verbally elaborate (e.g., due to migration or low socio-economic background) might be misunderstood because of language problems. Besides, beliefs might be domain specific for the area used in the scenario. A variety of scenarios in different areas and a researcher who speaks the same language or dialect as the subjects might be helpful in these cases.

Classroom studies and observations have become popular in the field of self-regulated learning. Children are observed in their well-known environment and material, procedures, and language is familiar to them. They do not have to answer strange questions about problems or issues they have never thought about before. But can such studies help to understand metacognitve reflection like strategies or beliefs? First results from the field of self-regulated learning research are encouraging. Children address strategies like planning, regulation, and control in their natural context in their own words. They also talk about some general epistemological beliefs. In order to validate the interpretations of this data, it might be helpful to videotape classroom observations and to use the method of stimulated recall to get a deeper understanding of what were important thoughts in a given situation.

Developmental issues clearly have to be addressed in future studies dealing with epistemological beliefs in early childhood. On a macro-level, longitudinal studies similar to those studies which were conducted with college students would help us to learn more about developmental pathways of epistemological beliefs in early childhood. On a micro-level process-oriented designs are necessary to find out which factors might foster conceptual changes in beliefs. Experiments with puzzling problems might be useful to shed light on this question.

There is a great need for more multi-method designs in research about epistemological beliefs in general and even more in research with young children. Results from studies with one method should be validated with results from other method in order to understand what was really measured. Although, it is quite common to use questionnaire and interview data the results have to be compared and correlated. From research in the field of learning strategies we already know that there might be serious problems to find correlations between results obtained with different measures. But multi-method designs allow us to detect difficulties and shortcomings in measures, to improve our ways of data collection, and finally lead to a deeper understanding of our subjects and their beliefs.

References

Baxter Magolda, M. B. (1992). *Knowing and reasoning in college: Gender-related patterns in students' intellectual development*. San Francisco, CA: Jossey Bass.

Baxter Magolda, M. B. (2002). Epistemological reflection: The evolution of epistemological assumptions from age 18 to 30. In B. K. Hofer & P. R. Pintrich (Eds.), *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 89–102). Mahwah, NJ: Erlbaum.

Belenky, M. F., Clinchy, B. M., Goldberger, N. R., & Tarule, J. M. (1986). *Women's way of knowing: The development of self, voice, and mind*. New York: Basic Books.

Boekaerts, M., & Markku, N. (2000). Self-regulated learning. Finding a balance between learning goals and ego-protective goals. In M. Boekaerts, P. Pintrich, & M. Zeidner (Eds.), *Handbook of self-regulation* (pp. 417–449). San Diego, CA: Academic Press.

Boekaerts, M., & Corno, L. (2005). Self-regulation in the classroom: A perspektive on assessment and intervention. *Applied Psychology*, 54(2), 199–231.

Butler, D. L. (2002). Qualitative approaches to investigating self-regulated learning: Contributions and challenges. *Educational Psychologist*, 37, 59–63.

Chandler, M. J., Hallett, D., & Sokol, B. W. (2002). Competing claims about competing knowledge claims. In B. K. Hofer & P. R. Pintrich (Eds.), *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 145–168). Mahwah, NJ: Erlbaum.

Clarebout, G., Elen, J., Luyten, L., & Bamps, H. (2001). Assessing epistemological beliefs: Schommer's questionnaire revisited. *Educational Research and Evaluation*, 7, 53–77.

Conley, A. M., Pintrich, P. R., Vekiri, I., & Harrison, D. (2004). Changes in epistemological beliefs in elementary science students. *Contemporary Educational Psychology*, 29, 186–204.

Corno, L. (2001). Volitional aspects of self-regulated learning. In B. J. Zimmerman & D. H. Schunk (Eds.), *Self-regulated learning and academic achievement: Theoretical perspectives* (2nd edn., pp. 191–226). Mahwah, NJ: Erlbaum.

Demetriou, A. (2000). Organization and development of self-understanding and self-regulation. In M. Boekaerts, P. Pintrich, & M. Zeidner (Eds.), *Handbook of self-regulation* (pp. 209–251). San Diego, CA: Academic Press.

Elder, A. D. (2002). Characterizing fifth grade students' epistemological beliefs in science. In B. K. Hofer & P. R. Pintrich (Eds.), *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 347–363). Mahwah, NJ: Erlbaum.

Ericsson, K. A., & Simon, H. A. (1980). Verbal reports as data. *Psychological Review*, 87(3), 215–251.

Ericsson, K. A., & Simon, H. A. (1993). *Protocol analysis*. Cambridge, MA: MIT Press.

Flavell, J. H., Green, F. L., & Flavell, E. R. (1995). Young children's knowledge about thinking. *Monographs of the Society for Research in Child Development*, 60(1), 1–96.

Garner, R. (1988). Verbal-report data on cognitive and metacognitive strategies. In C. E. Weinstein, E. T. Goetz, & P. A. Alexander (Eds.), *Learning and study strategies: Issues in assessment instruction, and evaluation*. Educational psychology (pp. 63–76). San Diego, CA: Academic Press.

Hallett, D., Chandler M. J., & Krettenauer, T. (2002). Disentangling the course of epistemic development: Parsing knowledge by epistemic content. *New Ideas in Psychology*, 20, 285–307.

Härle, F. C. (2006). *Personal epistemologies of 4th graders. Their beliefs about knowledge and knowing*. Oldenburg: Didaktisches Zentrum.

Harris, K. R., Graham, S., & Mason, L. H. (2006). Improving the writing, knowledge, and motivation of struggling young writers: Effects of self-regulated strategy development with and without peer-support. *American Educational Research Journal*, 43, 295–340.

Hayes, J. R., & Flower, L. S. (1980). Identifying the organization of writing process. In L. W. Gregg & E. R. Steinberg (Eds.), *Cognitive processes in writing* (pp. 3–30). Hillsdale, NJ: Erlbaum.

Hofer, B. (2004a). Epistemological understanding as a metacognitive process: Thinking aloud during online searching. *Educational Psychologist*, 39, 43–55

Hofer, B. K. (2004b). Exploring the dimensions of personal epistemology in differing classroom contexts: Students interpretations during the first year of college. *Contemporary Educational Psychology*, 29, 129–163.

Kuhn, D. (1991). *The skills of argument*. Cambridge, NY: Cambridge University Press.

Kuhn, D. (2000). Theorie of mind, metacognition, and reasoning: A life-span perspective. In K. J. Riggs & P. Mitchell (Eds.), *Children's reasoning and the mind* (pp. 301–326). Hove, UK: Psychology Press/Taylor & Francis.

Kuhn, D., Cheney, R., & Weinstock, M. (2000). The development of epistemological understanding. *Cognitive Development*, 15, 309–328.

King, P. M., & Kitchener, K. S. (1994). *Developing reflective judgement: Understanding and promoting intellectual growth and critical thinking in adolescents and adults*. San Francisco, CA: Jossey-Bass.

King, P. M., & Kitchener, K. S. (2002). The reflective judgement model: Twenty years of research on epistemic cognition. In B. K. Hofer & P. R. Pintrich (Eds.), *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 37–61). Mahwah, NJ: Erlbaum.

Kopp, C. B. (1982). Antecedents of self-regulation: A developmental perspective. *Developmental Psychology*, 18, 199–214.

Leopold, C., & Leutner, D. (2002). Der Einsatz von Lernstrategien in einer konkreten Lernsituation bei Schülern unterschiedlicher Jahrgangsstufen. *Zeitschrift für Pädagogik*, 45 (Beiheft), 240–258.

Lompscher, J. (1995a). *Erfassung von Lernstrategien mittels Fragebogen. Lern- und Lehrforschung, LLF-Berichte Nr. 10* (S. 80-150). Potsdam: Universität Potsdam.

Lompscher, J. (1995b). Learning strategies in 4th, 6th, and 8th grade students. In C. Aarnoutse, F. de Jong, H. Lodewijks, R. J. Simons, & D. v.d. Aalsvoort (Eds.), *Abstracts of the 6th European conference for research on learning and instruction* (p. 527). Nijmegen: University of Nijmegen.

Lompscher, J. (1996). Erfassung von Lernstrategien auf der Reflexionsebene. *Empirische Pädagogik*, 10, 245–275.

Mansfield, A. F., & Clinchy, B. McV. (2002). Toward the integration of objectivity and subjectivity: Epistemological development from 10 to 16. *New Ideas in Psychology*, 20, 225–262.

Meyer, D. K., & Turner, J. C. (2002). A classroom perspective on the principle of moderate challenge in mathematics. *Journal of Educational Research*, 97(6), 311.

Patrick, H., & Middleton, M. J. (2002). Turning the kaleidoscope: What we see when self-regulated learning is viewed with a qualitative lens. *Educational Psychologist*, 37, 27–39.

Perry, N. E. (1998). Young children's self-regulated learning. *The Journal of Educational Psychology*, 90(4), 715–728.

Perry, N. E., VandeKamp, K. O., Mercer, L. K., & Nordby, C. J. (2002). Investigating teacher-student interactions that foster self-regulated learning. *Educational Psychologist*, 37(1), 5–16.

Perry, W. G. (1970). *Forms of intellectual and ethical development in college years: A scheme*. New York: Holt, Rinehart & Winston.

Peterson, P. L., Swing, S. R., Braverman, M. T., & Buss, R. (1982). Students' aptitudes and their reports of cognitive processes during direct instruction. *Journal of Educational Psychology*, 82, 33–40.

Pintrich, P. R., Smith, D. A. F., Garcia, T., & McKeachie, W. J. (1993). Reliability and predictive validity of the motivated strategies for learning questionnaire (MSLQ). *Educational and Psychological Measurement*, 53, 801–813.

Pintrich, P. R. (2002). Future challenges and directions for theory and research on personal epistemology. In B. K. Hofer & P. R. Pintrich (Eds.), *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 389–413). Mahwah, NJ: Erlbaum.

Purdie, N., Hattie, J., & Douglas, G. (1996). Student conceptions of learning and their use of self-regulated learning strategies: A cross-cultural comparison. *Journal of Educational Psychology*, 88, 87–100.

Schommer, M. (1990). Effects of beliefs about the nature of knowledge on comprehension. *Journal of Educational Psychology*, 82, 498–504.

Schommer, M. (1994). An emerging conceptualization of epistemological beliefs and their role in learning. In R. Garner & P. A. Alexander (Eds.), *Beliefs about text and instruction with text* (pp. 25–40). Hillsdale, NJ: Lawrence Erlbaum.

Schommer-Aikins, M. (2002). An evolving theoretical framework for an epistemological belief system. In B. K. Hofer & P. R. Pintrich (Eds.), *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 103–118). Mahwah, NJ: Erlbaum.

Schommer, M., Crouse, A., & Rhodes, N. (1992). Epistemological beliefs and mathematical text comprehension: Believing it is simple does not make it so. *Journal of Educational Psychology*, 82, 435–443.

Schraw, G., Bendixen, L. D., & Dunkle, M. E. (2002). Development and validation of the epistemic belief inventory (EBI). In B. K. Hofer & P. R. Pintrich (Eds.), *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 261–275). Mahwah, NJ: Erlbaum.

Spoerer, N. (2004). *Validation of a structured interview for assessing self-regulated learning strategies*. Paper presented at the Annual Meeting of the American Educational Research Association, San Diego, CA.

Spoerer, N., & Brunstein, J. C. (2005). Diagnostik von selbstgesteuertem Lernen. In B. Moschner & C. Artelt (Eds.), *Lernstrategien und Metakognitionen – Implikationen für Forschung und Praxis*. Münster: Waxmann.

Souvignier, E., & Roes, K. (2005). Lernstrategien und Lernerfolg bei komplexen Leistungsanforderungen – Analysen mit Fragebogen und Lerntagebuch. In B. Moschner & C. Artelt (Eds.), *Lernstrategien und Metakognitionen – Implikationen für Forschung und Praxis*. Münster: Waxmann.

Turner, J. C. (1995). The influence of classroom contexts on young children's motivation for literacy. *Reading Research Quarterly*, 30, 410–441.

Veenman, M. V. J. (2005). The assessment of metacognitive skills: What can be learned from multi-method designs? In B. Moschner & C. Artelt (Eds.), *Lernstrategien und Metakognitionen – Implikationen für Forschung und Praxis*. Münster: Waxmann.

Veermans, M., & Järvelä, S. (2004). Generalized achievement goals and situational coping in inquiry learning. *Instructional Science*, 32, 269–291.

Weinstein, C. E. (1988). Assessment and training of student learning strategies. In R. R. Schmeck (Eds.), *Learning strategies and learning styles* (pp. 291–316). New York: Plenum.

Wild, K-P., & Schiefele, U. (1994). Lernstrategien im Studium. Ergebnisse zur Faktorenstruktur und Reliabilität eines neuen Fragebogens. *Zeitschrift für Differentielle und Diagnostische Psychologie*, 15, 185–200.

Winne, P. H., & Perry, N. E. (2000). Measuring self-regulated learning. In M. Boekaerts, P. P. Pintrich, & M. Zeidner (Eds.), *Handbook of self-regulation* (pp. 535–566). San Diego, CA: Academic Press.

Zimmerman, B. J., & Martinez-Pons, M. (1986). Development of a structured interview for assessing student use of self-regulated learning strategies. *American Educational Research Journal*, 23, 614–628.

Zimmermann, B. J., & Schunk, D. H. (Eds.) (2001). *Self-regulated learning and academic achievment: Theoretical perspectives* (2nd ed.). Mahwah, NJ:Erlbaum.

Zwaan, R. A., & Brown, C. M. (1996). The influence of language proficiency and comprehension skill on situation-model construction. *Discourse Processes*, 21, 289–327.

Part III
Empirical Studies on Cultural-specific Epistemology

Chapter 6
University Cultures and Epistemic Beliefs: Examining Differences Between Two Academic Environments

Krista R. Muis[1] **and Gale M. Sinatra**[2]

Abstract The purpose of this study was to examine how epistemic beliefs might differ between students sampled from culturally different academic institutions from two culturally similar countries. Undergraduate students were sampled from Simon Fraser University (SFU) in Canada and from the University of Nevada, Las Vegas (UNLV) in the USA. To examine differences across the five proposed dimensions in Schommer's (1990) multidimensional model, students completed Schraw et al.'s (2002) Epistemological Beliefs Questionnaire. Analyses of course syllabi and classroom observations were also conducted. Quantitative results revealed that SFU students espoused more constructivist epistemic beliefs. Course content and syllabi analyses and classroom observations revealed similarities across the two universities. Differences were found, however, in course design. SFU students participated in course-required tutorial sessions that included constructivist activities. We interpret the differences we found in students' epistemic beliefs are a result of the tutorial component required at SFU.

6.1 Introduction

A culture refers to the customs, arts, social institutions, and achievements of a particular nation, people or other social group. According to Jovchelovitch (2007), the culture within which we live structures our learning experiences and offers both the symbolic and material resources within which the dialectics between individuals and the social world are lived. Culture helps to construct the self and the interrelations that create phenomena such as communication and dialogue, social identities, social memory, public life, and social knowledge. Relatedly, Durkheim (1898) proposed that what keeps a community and culture together is social cohesion; a collection of representations that include shared beliefs. Given that communities are defined by their boundaries of different kinds, varying from

[1] *McGill University, Canada*

[2] *University of Nevada, Las Vegas, USA*

M. S. Khine (ed.), *Knowing, Knowledge and Beliefs: Epistemological Studies across Diverse Cultures.*

geographical, physical, religious, and cultural (Jovchelovitch, 2007), we might expect that individuals within a community, bounded by a specific culture, would hold similar beliefs to each other but may espouse disparate beliefs from those of other cultures.

6.2 Review of the Related Literature

Social science research on cultural differences has explored a number of belief constructs such as motivational beliefs (e.g., Casillas et al., 2006), self-advocacy beliefs (e.g., Hreinsdóttir et al., 2006), and self-efficacy beliefs (e.g., Klassen, 2004). Educational psychology researchers have also begun to explore cultural differences in students' beliefs about knowledge and knowing, or epistemic beliefs (e.g., Alexander & Douchy, 1995; Chan & Elliot, 2002; Dahlin & Regmi, 2000; Jacobson et al., 1997; Karabenick & Moosa, 2005; Kuhn & Park, 2005; Mason & Castiglioni, 2000; McDevitt et al., 1994; Nasser & Birenbaum, 2005; Qian & Pan, 2002; Youn, 2000). To better understand the nature of epistemic beliefs, researchers have sought to examine whether Schommer's (1990) multidimensional framework replicates across cultures (e.g., Arrendondo & Rucinski, 1996; Chan & Elliot, 2002, 2004; Mori, 1997; Nasser & Birenbaum, 2005), and whether similar relations are observed between epistemic beliefs and facets of cognition, motivation, and achievement (e.g., Nasser & Birenbaum, 2005). Cultural studies have also been conducted to examine the nature of epistemological development (e.g., Youn et al., 2001).

From a multidimensional perspective, Schommer (1990) proposed three independent dimensions of beliefs about knowledge that span along continua on: (1) the certainty of knowledge, ranging from knowledge is unchanging to knowledge is evolving; (2) the source of knowledge, ranging from knowledge is handed down by authority to knowledge is acquired through reason or logic; and (3) the simplicity of knowledge, ranging from knowledge is organized as isolated bits and pieces to knowledge is organized as highly interrelated concepts. She proposed two further dimensions related to learning. The fourth dimension of her model is (4) the control of knowledge acquisition, ranging from the ability to learn is inherited and unchangeable to the ability to learn can improve over time. The last dimension is (5) the speed of knowledge acquisition, ranging from learning is quick or not at all to learning is gradual.

In contrast to Schommer (1990), Hofer and Pintrich (1997) do not include beliefs about learning in their framework nor do they consider beliefs about knowledge and knowing as separate dimensions. Rather, they consider epistemic beliefs to be more theory-like, organized as structures of interrelated propositions that are interconnected and coherent. Consistent with more philosophical considerations of epistemology, Hofer and Pintrich clustered their dimensions into two areas that develop in a reasonable, predictable pattern: the nature of knowledge (what one believes knowledge is), and the nature or process of knowing (how one comes to know). Within each of these areas, there are two dimensions, for a total of four: (1)

the simplicity of knowledge, (2) the certainty of knowledge, which are included under the nature of knowledge, (3) the source of knowledge, and (4) the justification of knowledge, which fall under the nature or process of knowing.

Studies examining epistemic beliefs in Asian cultures have found that a belief in authority as the source of knowledge is an important factor for this group (e.g., Chan & Elliot, 2002, 2004; Lee, 1995). In contrast, studies with American samples generally have not found support for this proposed dimension (e.g., Schommer, 1990). This result has been interpreted as a difference in cultural values in different contexts, namely individualism in Western culture versus collectivism in Asian or Chinese culture (Bond, 1996; Triandis, 1995). Similar results have been reported with samples from other collectivist cultures from the Middle East (e.g., Karabenick & Moosa, 2005).

For example, Karabenick and Moosa (2005) compared Middle Eastern (Omani) and Western (US) college students' epistemic beliefs in the sciences across the four dimensions Hofer and Pintrich (1997) proposed. They found that Omani students were more likely to accept scientific authorities as the basis for scientific truth, and were more likely to believe that knowledge is simple and certain. Moreover, they found that Omani men were more accepting of authorities than were Omani women, whereas no gender differences were found with the US sample. Karabenick and Moosa attributed the results to differences in US and Omani students' traditions and religious backgrounds.

In another study, Nasser and Birenbaum (2005) examined differences between Jewish and Arab students in the eighth grade. They measured students' gender, epistemic beliefs, self-efficacy, attitudes, and anxiety toward mathematics, and mathematics achievement. Using multigroup structural equation modeling, Nasser and Birenbaum compared relations between the two groups and assessed whether students espoused different beliefs across the various constructs measured. They found the Arab group held more constructivist beliefs about mathematics. Moreover, although relations between the variables were similar across the two groups, they differed in the effects that gender, attitudes toward mathematics, and mathematics anxiety exerted on mathematics achievement. Given that the same curriculum was used across these two groups, Nasser and Birenbaum attributed differences to cultural as well as classroom contextual variables like instruction.

Based on cross-cultural research and research on epistemic beliefs in general, researchers have begun to discuss (e.g., Hofer, 2005) and develop (e.g., Muis et al., 2006) culturally inclusive models of epistemic beliefs. Recently, Muis et al. proposed the Theory of Integrated Domains in Epistemology (TIDE) framework founded on a wide sample of empirical studies. Consistent with Jovchelovitch's (2007) and Durkheim's (1898) positions on the effects of culture on individuals' knowledge and beliefs, Muis et al. argued that epistemic beliefs are complex and socially constructed and develop through interactions with the social world (see also Baxter Magolda, 2004; Belenky et al., 1986; Bendixen & Rule, 2004; Hofer & Pintrich, 1997; Jehng et al., 1993).

What individuals bring to interactions within their environment is an important factor in the TIDE framework. Fischer (1980) provides a developmental framework consistent with this notion of dynamic interaction between an individual and the environment. Similar to Piagetian theory, he proposed that individuals develop skills that provide a capacity to act in an organized way but, consistent with Vygotsky (1978), these skills are socially and culturally shaped. In the TIDE framework, it is the dynamic interaction of cognitive and brain capacities with environmental demands that characterize advancement in epistemic beliefs (see also King & Kitchener, 2004). Accordingly, to improve understanding of individuals' beliefs, we suggest researchers consider three different but related contexts: the larger societal and cultural context, the academic context, and the instructional context. Each of these perspectives allows a finer grained examination of how individuals' beliefs may develop within each context.

To extend this notion, Martin recently argued for less componential and more integrated views of the social nature of the self in educational psychology (Martin, 2007). Martin argues that current perspectives in educational psychology increasingly recognize the role of the social context in constructing the sense of self, or for our purposes, constructing individuals' beliefs about knowledge, but have yet to develop models that fully integrate the individual within the social. He notes that:

> most work in educational psychology stop[s] short of the more thoroughly collective conceptions of agency and selfhood found in much contemporary educational philosophy, sociology, and policy studies. (p. 83)

He argues that retaining a sense of individual agency is critical, but advocates a move toward viewing culture and contexts as not just factors to be considered but as fully integrated into our sense of individuals as "self-regulating agents … constituted within sociocultural practices of interactivity" (p. 83).

Relatedly, Jehng et al. (1993) also proposed that the acquisition of epistemic beliefs is a process of enculturation. Although little empirical work has examined the influences of broader contexts on individuals' beliefs, a few studies examined this issue (Estes et al., 2003; Hofer, 2000; Jehng et al., 1993; Paulsen & Wells, 1998; Schommer-Aikins et al., 2003). Jehng et al. (1993) posit that individuals' beliefs may be shaped by their surrounding culture and are by-products of given social contexts. Other research on cross-cultural differences supports this view and has revealed that individuals from diverse ethnic groups and cultural groups enter educational systems with varying world views (e.g., Gay, 1978; Pai, 1990).

Schraw (2001) similarly proposed that schools shape and change students' epistemic beliefs in a number of ways. Schools may influence beliefs through teacher modeling. That is, teachers' epistemic beliefs may influence students' epistemic beliefs. A recent study by Muis and Foy (2008) supports this hypothesis. Schools may also provide a "training ground" for students to develop critical thinking skills that allow them to think about, use, and modify their own views of knowledge.

Considering the studies that have been conducted to examine cross-cultural differences in students' epistemic beliefs, various hypothesized views of epistemic development, and Muis et al.'s (2006) theoretical framework, we sought to explore how students' epistemic beliefs might manifest as a function of the academic culture within which students learn. Specifically, as Muis et al. proposed, multiple contextual levels need to be considered to advance our understanding of the nature of epistemic beliefs. Accordingly, the purpose of our study is to examine how epistemic beliefs might differ between students sampled from culturally different academic institutions from two culturally similar countries.

6.3 The Cultural Context

We chose one Canadian university, Simon Fraser University (SFU), and one American university, University of Nevada, Las Vegas (UNLV), for an examination of academic cultural differences in relation to epistemic beliefs. Following the Carnegie Foundation Classification of Institutions of Higher Education (2005), SFU is classified as "research very high," the highest research classification; whereas UNLV is classified as "research high," the next level of research activity. These classifications are based on an index composed of factors such as research and development expenditures, number of research staff, and doctoral degree conferrals according to the Carnegie Foundation.

We identified five characteristics we thought would help contextualize each university's academic culture. The five chosen characteristics included: (1) student demographic information such as average age of entry and gender ratio, (2) minimum high school grade point average (GPA) required for entry, (3) funding for scholarships and grants, (4) funding from government, and finally, (5) percentage of students required to enroll in one or more remedial classes in their first year. We also explored how each university president characterized his respective university. Simon Fraser University is described first, followed by the University of Nevada, Las Vegas.

6.3.1 Simon Fraser University

Simon Fraser University was founded in 1965. Although it is one of Canada's younger universities, it continues to rank among the top three comprehensive universities in Canada based on MacLean's yearly university ranking system. As noted by SFU's president Michael Stevenson:

> in just four decades SFU has earned an international reputation for innovative teaching, research, athletics, and community outreach. With three distinctive campuses, more than 700 accomplished tenure-track faculty and nearly 22,000 talented students, SFU consistently ranks as one of Canada's leading comprehensive universities. In the classroom, the laboratory and even in the international arena, SFU continually sets new standards of excellence. SFU recently adopted new curriculum and admission requirements to increase the emphasis on writing and quantitative skills, as well as breadth of study, for undergraduates. SFU researchers have secured more than $50 million in sponsored funds, and lead their

> Canadian peers in attracting Social Sciences and Humanities Research Council and Canada Council grants. SFU finishes second in science and engineering grants and awards per full-time faculty. (2006)

Based on enrollment statistics from the 2004–2006 school years, 56.9% of all undergraduate students at SFU are female, and the average age of new admits is 20.7 with an overall average age of 23 for all undergraduates. The minimum requirement for entry from high school is a 3.2 GPA. A number of scholarships and grants are available to undergraduate students including entrance scholarships (totaling $3.95 million CAD each year), athletic and leadership scholarships (totaling $560,000), and grants totaling over $5.12 million. Moreover, the Ministry of Advanced Education in British Columbia allocated over $170 million for the 2006–2007 academic year. Finally, no students are required to enroll in one or more remedial classes in their first year.

6.3.2 University of Nevada, Las Vegas

Founded in 1957, UNLV is considered to be an emerging urban research university. President David Ashley notes that UNLV is a

> culturally diverse campus community. With approximately 28,000 undergraduate, graduate, and professional students and a complement of faculty scholars numbering nearly 3,000, UNLV offers students a wide range of rich cultural, athletic and campus involvement opportunities as well as the highest quality educational experience. As an emerging research university in a dynamic environment, UNLV offers a truly research-enriched academic program, with unique opportunities for both undergraduate and graduate students to work with leading scholars in all disciplines. (2006)

Based on enrollment statistics from the 2004–2005 school year, and similar to SFU, 55.9% of all undergraduate students at UNLV are female, and the average age of undergraduate students is 24. A number of scholarships and grants are also available to undergraduate students at UNLV. Scholarships total over $25.5 million USD per year (which include entrance, endowed, non-endowed, and athletic scholarships), and grants total over $30.6 million (for both grants and grants-in-aid). UNLV received close to $91 million from the State of Nevada for the 2004–2005 academic year. Moreover, UNLV faculty have secured over $90 million in grants and contracts. In contrast to SFU, the minimum requirement for entry as a freshman to UNLV from high school is a 2.75 GPA, which was implemented only recently. Previous to the implementation of this GPA requirement, no set minimum was used. Finally, approximately 10% of all first year students must enroll in remedial mathematics or English courses or both.

Based on differences between the classifications and various statistics we obtained about the universities, we inferred the cultural environment between them had significant differences. SFU could be characterized as having the highest level of research activity, exceptionally competitive entrance requirements, and academically well-prepared students in a country with strong social support systems in place for its citizens. In contrast, UNLV could be characterized as an emerging research institution, dedicated to provide the opportunity of higher education to virtually all Nevadans (until the recent imposition of a GPA requirement), with students who show great variability in their preparedness for college-level work, in a country and state with less social and economic support structures than its Canadian neighbor.

Accordingly, we examined whether these cultural differences would be reflected in students' epistemic beliefs. We measured students' epistemic and learning beliefs along the five dimensions Schommer (1990) proposed in her multidimensional model: epistemic beliefs about the certainty of knowledge, structure of knowledge, and sources of knowledge, and learning beliefs about the speed of learning, and innate ability. Because previous research has found that GPA is correlated to epistemic beliefs (e.g., Paulsen & Wells, 1998; Schommer-Aikins et al., 2005), and SFU requires a higher GPA for admission, we measured students self-reported GPA to use as a covariate in our analyses.

6.4 Methodology

6.4.1 Participants

One hundred and twenty-seven students from SFU in Canada (N = 65 females) and 138 students from UNLV in the USA (N = 95 females) were sampled from undergraduate-level mathematics courses. The mean age of students from SFU was 20.80 years (SD = 4.12), and the mean self-reported GPA was 3.19 (SD = .53). The mean age of students from UNLV was 24.69 years (SD = 8.81), and the mean self-reported GPA was 3.27 (SD = .55). Distribution of year of study was equivalent across the universities. All participants received and signed a university research ethics board approved consent form.

6.4.2 Measures

6.4.2.1 Demographics Questionnaire

A demographics questionnaire was designed to measure various characteristics of the samples. Students were asked to report information on their age, gender, cumulative grade point average in all post-secondary courses, cumulative grade point average in all mathematics/statistics courses, academic major, and academic minor. The questionnaire also asked students to report the number of courses in which they were enrolled for the current semester, total number of courses taken, year of study, average hours worked per week, average hours studying per week, and whether English was their first spoken and written language and, if not, at what age they learned to speak and write English.

6.4.2.2 Epistemic Beliefs Inventory

The Epistemic Belief Inventory (EBI; Schraw et al., 2002) was used to measure students' beliefs about knowledge, knowing, and learning. This inventory includes 28 self-report items designed to measure students' beliefs on the five dimensions Schommer (1990) proposed in her model. These dimensions include the certainty of knowledge (seven items), the source of knowledge (four items), the structure of knowledge (seven items), the control of knowledge acquisition (six items), and the speed of knowledge acquisition (four items). Students rate each item on a 5-point rating scale ranging from "strongly disagree" (a rating of 1) to "strongly agree" (a rating of 5). A sample item from the certainty of knowledge subscale is "What is true today will be true tomorrow." A sample item from the source of knowledge subscale is "People shouldn't question authority." A sample item from the structure of knowledge subscale is "The best ideas are often the most simple." A sample item from the control of knowledge acquisition subscale is "People's intellectual potential is fixed at birth." Finally, a sample item from the speed of knowledge acquisition is "If you don't learn something quickly, you won't ever learn it." For all of these subscales, a lower score reflects stronger disagreement to items and therefore, a more "constructivist" view of knowledge (Stathopoulou & Vosniadou, in press). A constructivist personal epistemology reflects beliefs that knowledge is constructed by individuals within a social context, and thus is constantly changing and flexible.

Schraw et al. (2002) assessed the reliability and validity of the EBI and found support for the five proposed dimensions and reported reliability estimates (both internal consistency and test–retest) and construct and predictive validity consistent with Schommer's (1990) Epistemological Questionnaire (SEQ). Internal consistency coefficients for the five subscales ranged from .58 to .68, and test–retest reliability estimates ranged from .62 to .81.

6.4.3 Procedure

Participants spent approximately 20 min completing the demographics and EBI questionnaires.

6.5 Results

Data were screened for normality. Using the Kolmogorov-Smirnov test for normality, all scales' scores were normally distributed with skewness and kurtosis values within acceptable ranges (all $p > .001$). Means, standard deviations, and reliability

Table 6.1 Means, standard deviations, and reliability estimates for the five dimensions of the EBI across the two samples

	Authority	Certain knowledge	Quick learning	Simple knowledge	Innate ability
Group	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
SFU	2.76 (.69)	2.38 (.57)	1.99 (.56)	2.72 (.64)	3.16 (.71)
UNLV	3.31 (.61)	2.65 (.55)	2.01 (.76)	2.97 (.69)	2.98 (.76)
α	.52	.58	.59	.68	.70

Note: SD = standard deviation.

coefficients are presented in Table 6.1. Reliability estimates for the subscales on the EBI ranged from .52 to .70. These estimates are consistent with estimates reported in previous research (e.g., Schraw et al., 2002).

A multivariate analysis of variance was conducted to examine differences across the two samples while controlling for GPA. Results revealed a significant overall difference between groups using Pillais' criterion, $F(5, 209) = 10.24$, $p < 01$, $n^2 = .20$, and a significant covariate, $F(5, 209) = 6.38$, $p < .01$, $n^2 = .13$. Univariate tests indicated significant differences between groups on all three epistemic beliefs' dimensions: beliefs about authority as the source of knowledge, $F(1, 213) = 36.66$, $p < .01$, $n^2 = .15$, beliefs about the certainty of knowledge, $F(1, 213) = 11.25$, $n^2 = .05$, and beliefs about the structure of knowledge, $F(1, 213) = 3.76$, $p < .01$, $n^2 = .04$. Each difference showed the same pattern. SFU students consistently reported more constructivist beliefs about knowledge than students in the UNLV sample. No differences were found on either of the two learning beliefs dimensions: beliefs about the speed of learning, and beliefs about innate ability (both $p > .05$).

6.5.1 Ancillary Analyses

To further explore contextual differences, we conducted content analyses and classroom observations of some of the mathematics courses from which we sampled our participants. Using course syllabi, we examined the textbooks used, the content covered, and course requirements (e.g., quizzes, assignments, exams, etc.) for five courses at various years of study across the two universities. The courses included: Calculus I, Calculus II, Calculus III, Linear Algebra, and Geometry. Our analyses revealed that the same textbooks, content, and course requirements were used for all calculus courses. Moreover, similar content and course requirements were used for the other two courses even though they used different textbooks. Classroom observations across a wider range of courses also revealed similarities across the two universities. At both universities, traditional methods of teaching were used; instructors covered material through lectures and demonstration of problem sets.

The only major difference we identified was the tutorial requirement at SFU. Undergraduate courses at SFU include two components – a traditional lecture component whereby professors cover course content, and a tutorial component led by a teaching assistant. Typically, tutorial sessions were student centered; students engaged in collaborative work to solve problems, sought assistance, and discussed problem solutions with the teaching assistant. Specifically, during tutorials, students were engaged in a more constructivist approach to learning.

6.6 Discussion

Our results indicate an interesting pattern of cultural differences in epistemic beliefs between students in these two academic and sociocultural contexts. We examined the demographic characteristics and the cultural and academic contexts across both groups and found differences that may be important factors that contribute to the development of epistemic beliefs. In particular, SFU students were well prepared for college (based on their entering GPAs), and attended a university with a well-established research culture within a country with strong economic and social support systems. In contrast, UNLV students were less well prepared for college (as evidenced by the remedial course enrollment rates), and attended a university with an emerging research culture in an ethnic and socioeconomically diverse urban context with significantly less social and economic support.

We wondered whether these contextual differences would be reflected in different course experiences for students attending these two universities. A cursory examination of the course syllabi for five mathematics courses at SFU and five mathematics courses at UNLV revealed that this not-necessarily representative sample did not differ in content or course requirements. Moreover, classrooms observations revealed no qualitative differences in method of content delivery; instruction was typically lecture based. The major difference we observed between the two universities was the tutorial requirement at SFU.

Given the constructivist nature of the tutorials at SFU, we interpret these two institutions may have different expectations for their students. Whether the instructors have deliberately designed their courses and tutorials to match the academic developmental level of their students or not, differences in expected level of content engagement at the two institutions clearly differ. SFU students were expected to constructively engage in content during tutorial sessions, whereas UNLV students are not provided these additional opportunities within the structure of their course requirements (whether they had these opportunities outside the course structure, such as student formed study groups or individual tutoring we can not determine). The nature of the activities required of them suggests that the SFU students may have engaged in more critical examination of knowledge than UNLV students as part of their course requirements.

These results are consistent with Hofer's (1999) findings in her research on instructional contexts. She examined relationships among students' beliefs and motivation, learning strategies, and academic performance in two different instructional contexts in introductory calculus. One instructional context used traditional methods; instructors used a standard calculus text that proceeded sequentially, and were expected to cover a required amount of material primarily through lectures and demonstrations of problem sets. The alternative instructional context, called the "New Wave" approach, used more social-constructivist approaches where collaborative learning was emphasized, students engaged in active learning and were expected to work situated problems with potentially multiple approaches and more complex solutions.

Hofer (1999) found that more constructivist beliefs were significantly positively correlated with intrinsic motivation, self-efficacy, and self-regulation, as well as with course grades. Moreover, at the end of the term, based on group means, students enrolled in the "New Wave" sections exhibited more constructivist beliefs than students enrolled in the traditional style instruction sections. Students in classes that emphasized active learning were less likely to believe that the structure of mathematics knowledge was simple.

Taken together, these results are important to consider. If universities adopt a tutorial or classroom policy that affords students opportunities to engage in constructivist activities, this may promote the development of students' epistemic beliefs toward a more constructivist view of knowledge. Given the positive relations research has found between more constructivist beliefs and facets of cognition, motivation, and achievement (see Muis, 2004; Muis et al., 2006), further consideration of this suggestion is warranted.

There are, however, significant limitations to this initial foray into academic cultures and their influence on epistemic beliefs. Clearly, much more work is needed to support these preliminary ideas expressed herein. However, we believe that examinations of the academic culture are a critical area for extending our understanding of the development of epistemic beliefs within cultural contexts. Recently, Alexander and Sinatra (2007) argued that the Model of Domain Learning (Alexander, 1997, 2005) provides a useful framework for understanding how views of knowledge develop within an academic context. They argue that "as one acquires a richer knowledge base, and moves toward expertise in a domain, one becomes able to see the complexity of ideas and understand multiple sides of an issue. This appreciation for the complex and evolving nature of knowledge promotes opportunities for epistemic change (Sinatra, 2005)" (p. 228).

Alexander and Sinatra (2007) argue that evidence is emerging which suggests that epistemic development may be more a result of a Western academic orientation toward knowledge and knowing than a developmental progression as others have argued (Bendixen & Rule, 2004). Karabenick and Moosa's (2005) results described earlier revealed that college students in their sample were more absolutists and were more likely to view authorities as knowledge sources than their US counterparts. Similarly, Weinstock (2005)'s study of ethnic and gender differences in seventh- and ninth-grade Bedouin students' epistemic development showed that these students were more likely to be absolutist in orientation than Jewish students of the same grade level. This suggests there is likely both a developmental and cultural component to epistemic belief development. These results also highlight that viewing evaluativist thinking as the developmental objective or placing value-laden labels such as “more sophisticated” on evaluativist thought reflects a Western, academic perspective. Alexander and Sinatra point out that

> valuing of complex and nuanced views of knowledge may be unique to those in the academy who may not share the beliefs about knowledge and knowing prevalent within the broader cultural community to which they belong. (p. 229)

In closing, much more work is needed to examine the nuanced differences between two ostensibly similar cultures as we examined, that is, the Canadian and American cultures in which these two universities are embedded. Too often in cross-cultural research, we compare cultures that appear to be radically different in their world views. This research helps highlight markedly different views. And yet, much may be learned by comparing cultures with more subtle distinctions. Canadian and American cultures share many historical and cultural similarities, but are unique in many ways regarding values and ideas. Since these are precisely the differences that may contribute to epistemic development, exploring these nuances may bring about a greater understanding of culturally embedded epistemic belief development.

Acknowledgments The research reported in this article was supported by a graduate fellowship from Simon Fraser University to Krista R. Muis as well as a New Investigator Award (NIA 2220-273-767G-Muis) from the University of Nevada, Las Vegas. The opinions expressed in this article are the authors’ and do not reflect the positions or policies of Simon Fraser University or the University of Nevada, Las Vegas.

Correspondence concerning this article should be addressed to Krista R. Muis, McGill University, 3700 McTavish St., Montreal, Quebec, H3A 1Y2. Electronic mail may be sent via internet to Krista.Muis@McGill Phone: 514-398-3445. Fax: 514-398-6968.

References

Alexander, P. A. (1997). Mapping the multidimensional nature of domain learning: The interplay of cognitive, motivational, and strategic forces. In M. L. Maehr & P. R. Pintrich (Eds.), *Advances in motivation and achievement* (Vol. 10, pp. 213–250). Greenwich, CT: JAI Press.

Alexander, P. A. (2005). Teaching towards expertise [Special Monograph on Pedagogy – Learning for Teaching]. *British Journal of Educational Psychology*. Monograph Series II, 3, 29–45.

Alexander, P. A., & Douchy, F. J. (1995). Conceptions of knowledge and beliefs: A comparison across varying cultural and educational communities. *American Educational Research Journal*, 32, 413–442.

Alexander, P. A., & Sinatra, G. M. (2007). First steps: Scholar’s promising movements into a nascent field of inquiry. In S. Vosniadou, A. Baltas, & X. Vamvakoussi (Eds.), *Reframing the conceptual change approach in learning and instruction*, (pp. 221–236). Oxford: Elsevier.

Arrendondo, D. E., & Rucinski, T. T. (1996). *Epistemological beliefs of Chilean educators and school reform efforts*. Paper presented at the Tercer Encuentro National de Enfoques Actuales on education Pontificia Universidad Catohea Chile Santiago de Chile.

Baxter Magolda, M. B. (2004). A constructivist conceptualization of epistemological reflection. *Educational Psychologist*, 39(1), 31–42.

Belenky, M., Clinchy, B., Goldberger, N., & Tarule, J. (1986). *Women’s ways of knowing: The development of self, voice, and mind*. New York: Basic Books.

Bendixen, L. D., & Rule, D. C. (2004). An integrative approach to personal epistemology: A guiding model. *Educational Psychologist*, 39(1), 69–80.

Bond, M. H. (1996). *The handbook of Chinese psychology*. Hong Kong: Oxford University Press.

Casillas, A., Schulz, E. M., & Robbins, S. B. (2006). Exploring the meaning of motivation across cultures: IRT analyses of the goal instability scale. *Journal of Career Assessment*, 14, 472–489.

Chan, K., & Elliot, R. (2002). Exploratory study of Hong Kong teacher education students' epistemological beliefs: Cultural perspectives and implications on beliefs research. *Contemporary Educational Psychology*, 27, 392–414.

Chan, K., & Elliot, R. (2004). Relational analysis of personal epistemology and conceptions about teaching and learning. *Teaching and Teacher Education*, 20, 817–831.

Dahlin, B., & Regmi, P. M. (2000). Ontologies of knowledge, East and West – A comparison of the views of Swedish and Nepalese students. *International Journal of Qualitative Studies in Education*, 13, 43–61.

Durkheim, E. (1898/1996). Représentations individuelles et representations collectives. In E. Durkheim, *Sociologie et philosophie*. Paris: Presses Universitaires de France.

Estes, D., Chandler, M., Horvath, K. J., & Backus, D. W. (2003). American and British college students' epistemological beliefs about research on psychological and biological development. *Applied Developmental Psychology*, 23, 625–642.

Fischer, K. W. (1980). A theory of cognitive development: The control and construction of hierarchies of skills. *Psychological Review*, 87, 477–531.

Gay, G. (1978). Viewing the pluralistic classroom as a cultural microcosm. *Educational Research Quarterly*, 45–49.

Hofer, B. K. (1999). Instructional context in the college mathematics classroom: Epistemological beliefs and student motivation. *Journal of Staff, Program, and Organizational Development*, 16, 73–82.

Hofer, B. K. (2000). Dimensionality and disciplinary differences in personal epistemology. *Contemporary Educational Psychology*, 25, 378–405.

Hofer, B. K. (2005). *Developing culturally inclusive models of epistemic beliefs: A roundtable discussion*. Paper presented at the meeting of the American Educational Research Association, Montreal, Canada.

Hofer, B. K., & Pintrich, P. R. (1997). The development of epistemological theories: Beliefs about knowledge and knowing and their relation to learning. *Review of Educational Research*, 67, 88–140.

Hreinsdóttir, E. E., Stefánsdóttir, G., & Lewthwaite, A. (2006). Is my story so different than yours? Comparing life stories, experiences of institutionalization and self-advocacy in England and Iceland. *British Journal of Learning Disabilities*, 34, 157–166.

Jacobson, M. J., Jehng, J., & Maouri, C. (1997). *The cultural and domain specificity of epistemological beliefs: A cross-cultural comparison of Taiwanese and American university students*. Paper presented at the annual meeting of the American Educational Research Association, New York.

Jehng, J. J., Johnson, S. D., & Anderson, R. C. (1993). Schooling and students' epistemological beliefs about learning. *Contemporary Educational Psychology*, 18, 23–35.

Jovchelovitch, S. (2007). *Knowledge in context: Representations, community, and culture*. New York: Routledge.

Karabenick, S. A., & Moosa, S. (2005). Culture and personal epistemology: U.S. and Middle Eastern students' beliefs about scientific knowledge and knowing. *Social Psychology of Education*, 8, 37–393.

King, P. M., & Kitchener, K. S. (2004). Reflective judgment: Theory and research on the development of epistemic assumptions. *Educational Psychologist*, 39(1), 5–18.

Klassen, R. M. (2004). A cross-cultural investigation of the efficacy beliefs of South Asian immigrant and Anglo Canadian nonimmigrant early adolescents. *Journal of Educational Psychology*, 96, 731–742.

Kuhn, D., & Park, S. (2005). Epistemological understanding and the development of intellectual values. *International Journal of Educational Research*, 43, 111–124.

Lee, B. (1995). *Differences in the epistemological beliefs of Korean and American graduate students and their influence on the academic writing task*. Ph.D. dissertation, University of Texas, Austin, TX.

Mason, L., & Castiglioni, M. (2000). Students' beliefs about the nature and acquisition of knowledge. An application of the Epistemic Beliefs Inventory. *Ricerche di Psicologia*, 24, 165–188.

Martin, J. (2007). The selves of educational psychology: Conceptions, contexts, and critical considerations. *Educational Psychologist*, 42, 79–89.
McDevitt, T. M., Sheehan, E. P., Cooney, J. B., Smith, T., & Walker, B. (1994). Conceptions of listening, learning processes, and epistemologies held by American, Irish, and Australian university students. *Learning & Individual Differences*, 6, 231–256.
Mori, Y. (1997). *Epistemological beliefs and language learning beliefs: What do language learners believe about their learning?* Paper presented at the annual meeting of the American Educational Research Association, Chicago, IL.
Muis, K. R. (2004). Personal epistemology and mathematics: A critical review and synthesis of research. *Review of Educational Research*, 74, 317–377.
Muis, K. R., Bendixen, L. D., & Haerle, F. (2006). Domain-generality and domain-specificity in personal epistemology research: Philosophical and empirical reflections in the development of a theoretical framework. *Educational Psychology Review*, 18(1), 3–54.
Muis, K. R., & Foy, M. J. (2007). The multilevel effects of teachers' epistemic beliefs on student achievement. In L. D. Bendixen & F. Haerle (Eds.), *Personal epistemology in the classroom: Theory, research, and implications for practice*. NY: Cambridge University Press.
Nasser, F., & Birenbaum, M. (2005). Modeling mathematics achievement of Jewish and Arab eighth graders in Israel: The effects of learner-related variables. *Educational Research and Evaluation*, 11, 277–302.
Pai, Y. (1990). *Cultural foundations of education*. Columbus, OH: Merrill Publishing Company.
Paulsen, M. B., & Wells, C. T. (1998). Domain differences in the epistemological beliefs of college students. *Research in Higher Education*, 39, 365–384.
Qian, G. & Pan, J. (2002). A comparison of epistemological beliefs and learning from science text between American and Chinese high school students. In B. K. Hofer & P. R. Pintrich (Eds.), *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 365–385). Mahwah, NJ: Lawrence Erlbaum.
Schommer, M. (1990). Effects of beliefs about the nature of knowledge on comprehension. *Journal of Educational Psychology*, 82, 498–504.
Schommer-Aikins, M., Duell, O. K., & Barker, S. (2003). Epistemological beliefs across domains using Biglan's classification of academic disciplines. *Research in Higher Education*, 44, 347–366.
Schommer-Aikins, M., Duell, O. K., & Hutter, R. (2005). Epistemological beliefs, mathematical problem-solving beliefs, and academic performance of middle school students. *Elementary School Journal*, 289–304.
Schraw, G. (2001). Current themes and future directions in epistemological research: A commentary. *Educational Psychology Review*, 13, 451–465.
Schraw, G., Bendixen, L. D., & Dunkle, M. E. (2002). Development and validation of the epistemic belief inventory. In B. K. Hofer & P. R. Pintrich (Eds.), *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 261–275). Mahwah, NJ: Lawrence Erlbaum.
Sinatra, G. M. (2005). The "warming trend" in conceptual change research: The legacy of Paul Pintrich. *Educational Psychologist*, 40, 107–115.
Stathopoulou, C., & Vosniadou, S. (in press). Conceptual change in physics and physics-related epistemological beliefs: A relationship under scrutiny. In S. Vosnidou, A. Baltas, & X. Vamvakoussi (Eds.), *Re-framing the problem of conceptual change in learning and instruction*. Elsevier.
Triandis, H. C. (1995). *Individualism and collectivism*. Boulder, CO: Westview.
Vygotsky, L. S. (1978). *Mind and society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press.
Weinstock, M. (2005, August). Grade level, gender, and ethnic differences in epistemological understanding within domains. In F. Hearle, & L. Bendixen (Co-chairs), *Current research in children's personal epistemology: Implications for developmental aspects of learning and instruction*. Symposium presented at the meeting of the European Association for Research in Learning and Instruction, Nicosia, Cyprus.
Youn, I. (2000). The culture specificity of epistemological beliefs about learning. *Asian Journal of Social Psychology*, 3, 87–105.

Chapter 7
Personal Epistemology in Elementary Classrooms: A Conceptual Comparison of Germany and the United States and a Guide for Future Cross-Cultural Research

Florian C. Haerle and Lisa D. Bendixen

Abstract Our understanding of the cross-cultural aspects of personal epistemology is limited. In particular, cross-cultural comparisons of elementary school teachers' and students' personal epistemology have received very little theoretical or empirical attention. The current chapter aims to examine German and U.S. elementary schools in terms of their philosophical and practical similarities and differences in personal epistemology. Both theoretical and empirical work will be reviewed to support a more holistic model of personal epistemology, the Educational Model of Personal Epistemology (Haerle, 2006). In light of this model, we discuss our expectations for differences and similarities in the epistemic climate of elementary classrooms in the U.S. and Germany. Drawing from this discussion, we suggest that researchers should approach cross-cultural research in personal epistemology from a more holistic standpoint, employ a diversity of methods, and obtain a solid understanding of the educational context under study. Regarding educational implications, we propose a possible fusion of the educational philosophies held in the U.S. and Germany concerning the implementation of teacher training and classroom education. Finally, we recommend that fostering evaluativistic thinking (i.e., a way of knowing that focuses on the evaluation and decision-making among differing viewpoints) should be a main goal for education starting at the elementary level to ensure students' future roles as productive citizens in Western societies and stress the role of the teacher in this endeavor.

7.1 Introduction

Currently, our understanding of the cross-cultural aspects of personal epistemology (i.e., conceptions about the nature of knowledge and knowing) is limited and a number of researchers have called for more studies to pursue this important area of inquiry (Chan & Elliott, 2004; Hofer & Pintrich, 2002; Pintrich, 2002). In particular, cross-cultural comparisons of elementary school teachers' and students' personal epistemology have received very little theoretical or empirical attention. The purpose of the current chapter is to examine the epistemic climate of elementary

Department of Educational Psychology, University of Nevada, Las Vegas, USA

M. S. Khine (ed.), *Knowing, Knowledge and Beliefs: Epistemological Studies across Diverse Cultures.*

education in Germany and the United States. We use the term epistemic climate to describe aspects of knowledge and knowing within an educational environment. Clarifying the educational similarities and differences in these Western cultures and how they may impact the epistemic climate of elementary classrooms have important implications for classroom practice, student learning, and teacher education programs.

7.1.1 Personal Epistemology

In general, four theoretical frameworks can be identified in the literature on personal epistemology. They conceptualize personal epistemology as: (1) a development of epistemological thinking (e.g., Baxter Magolda, 1992; Perry, 1970), (2) epistemological beliefs (e.g., Schommer, 1990), (3) epistemological theories (e.g., Hofer & Pintrich, 1997), and (4) epistemological resources (e.g., Hammer & Elby, 2002).

For the purposes of this chapter we chose to use the Hofer and Pintrich (1997) conception of personal epistemology. Personal epistemology is viewed as individuals' epistemological theories. These personal theories encompass four identifiable dimensions, which are interrelated and proposed to develop in reasonable, predictable directions. The first two dimensions concern the *nature of knowledge* in terms of: (1) *the certainty of knowledge* (i.e., the stability of knowledge and the strength of the supporting evidence) and (2) *the simplicity of knowledge* (i.e., the relative connectedness of knowledge). The third and fourth dimensions describe the *nature of knowing* and pertain to: (3) *the justification of knowledge* (i.e., the procedures to evaluate and warrant knowledge claims) and (4) *the source of knowledge* (i.e., where knowledge resides; internally and/or externally).

Personal epistemology has been a focal point of educational research in North America over the last 40 years (for a review, see Hofer & Pintrich, 1997). There is a growing consensus that epistemological thinking matters in our every day lives (Kuhn & Weinstock, 2002). In terms of educational implications, epistemological beliefs have been found to be related to a variety of factors including reasoning skills (Chandler et al., 1990), strategy use (Schommer et al., 1992), cognitive processing (Kardash & Howell, 2000), conceptual change (Qian & Alvermann, 2000), and moral reasoning (Bendixen, Schraw, & Dunkle, 1998).

7.1.2 Cross-cultural Research in Personal Epistemology

From a Vygotskian perspective, it is generally assumed that epistemological theories are socially constructed and, therefore, culture would play an important role in the development of epistemological beliefs (Hofer & Pintrich, 1997; Pintrich, 2002; Qian & Pan, 2002; Vygotsky, 1978). The body of theory and research associated with personal epistemology has focused on North American samples of older adolescents and college-aged students (e.g., Hofer, 2000; King & Kitchener, 1994; Perry, 1970; Schommer, 1990). A small number of studies have begun to address the need for research looking across cultures to investigate similarities and differences in the epistemological beliefs of students and teachers and the more general educational implications that stem from these findings (Chan & Elliott, 2004; Hofer & Pintrich, 1997).

What cross-cultural research that does exist focuses mainly on the dimensions of epistemological beliefs (Schommer, 1990) and how they differ in North American and Non-Western cultures (e.g., China, Hong Kong, Japan, and Taiwan) (Chan & Elliott, 2004). For example, it is hypothesized that in Asian school cultures there is an emphasis on collectivism, acceptance of consensus, respecting authority, and the importance of effort in academic achievement (Chan & Elliott, 2004; Qian & Pan, 2002). In contrast, North American educational values of democracy, independent thinking, and individualism influence beliefs about knowledge and knowing (Hofer & Pintrich, 1997). Differences have been detected in students' and teachers' personal epistemologies and cultural patterns such as these are beginning to emerge in the research literature. For example, on a rough continuum ranging from naive to sophisticated beliefs about the *source of knowledge,* teachers and students in Asia tend to believe more in external, authoritative sources such as experts (Chan & Elliot, 2000; Lin, 2001; Qian & Pan, 2002; Tsai, 2002), while their North American and Australian counterparts rely on a combination of external and internal knowledge sources (e.g., Brownlee, Purdie, & Boulton-Lewis, 2001; Schraw & Olafson, 2002; White, 2000).

In summary, there is a growing body of research to suggest that personal epistemology is influenced by culture, but much more empirical and theoretical work needs to be done along these lines. For example, to more fully understand how culture impacts personal epistemology (and vice versa) more theoretical and empirical cross-cultural comparisons need to be done.

The majority of the cross-cultural studies that have been done have focused on the impact of Eastern and North American cultures. One promising avenue for personal epistemology research is to more closely examine the distinctions among cultures that fall within the Western category. Do all Western countries share the North American view of education? Are there important similarities and differences in Western cultures? How do differing educational values in Western cultures impact the epistemologies of elementary teachers, students, curriculum, and pedagogy?

In support of these questions, the current chapter aims to examine German and U.S. elementary schools in terms of their similarities and differences in personal epistemology. Both theoretical and empirical work will be reviewed to support a more holistic model of personal epistemology. This conceptual comparison will help clarify current understandings and guide future research in cross-cultural aspects of personal epistemology in the elementary school context.

7.2 Similarities and Differences in German and U.S. Elementary Schools

To help further understand personal epistemology through a cross-cultural lens, the following section provides a philosophical and practical comparison of German and U.S. elementary schools. This comparison is based on both theoretical and empirical work and offers crucial information regarding how these cultures contrast in terms of educational views and what they have in common in approaching the task of educating children. Finally, it is important to note that this comparison is not exhaustive nor does it completely cover the current educational debates and changes occurring in both cultures.

7.2.1 Philosophical Similarities

The elementary school systems in Germany and the U.S. share aspects of their educational philosophy. One aspect is the aim to purposefully ensure the cultural identity of each society and to maintain its educated level in future generations. This entails the promotion of (1) cultural communication to enable the individual to communicate with other members of the same culture, and (2) cultural loyalty by fostering the acceptance and sharing of norms, values, and routines, and the desire to have them remain (Gudions, 1994; Meyer & Vogt, 1997; Purves, 1988; Weinreich, 1963). This is reflected in the goal to provide all students with a basic understanding of literacy and numeracy and to establish foundations in science, geography, history, and social sciences.

Another shared educational philosophy is to ensure and advance equality in and through education. Both Western educational systems aim to account for sociocultural, academic equality and social justice. They are designed to teach and educate all students in this age range and guide children toward good citizenship (Whitebread, 2000). The motivation behind this philosophy and some strategies of implementing it into practice, however, differ between these countries.

7.2.2 Philosophical Differences

According to Gundem and Hopmann (1998) there are two basic models of Western education and its notion of learning and instruction: (1) the Anglo-Saxon (i.e., North American) tradition of *curriculum studies*, or educational psychology and (2) the German (or Continental European) tradition of *Didaktik*. Didaktik and U.S. curriculum studies are conceived by some to be very different philosophies of education and remain "embedded in very different practical, cultural, and structural contexts. They are very different intellectual systems developed out of very different starting points, and seek to do very different kinds of intellectual and practical work" (Westbury, 1998, p. 48). Differences fall along the lines of their focus on the core of teaching practice and in the role of the teacher in the educational setting. While some argue that the division is not that clear and differences are not that extreme (Autio, 2006), a comparison of German and U.S. educational philosophies offers important insights into cross-cultural understandings of the educational implications of personal epistemology research.

German Educational Philosophy. The origins of the German tradition of Didaktik can be traced back to the writings of Wolfgang Radtke (1571–1635) and Johann Comenius (1592–1670) who proposed a general method for the analysis of teaching and Johann Herbart's (1776–1841) principle of education through instruction (Kansanen, 1995). The term Didaktik has many meanings and is difficult to translate into English. It characterizes, in English, "the teaching-studying-learning process" (Kansanen, 2002, p. 430).

Didaktiks is part of a greater system of a societal process called *Bildung*, which refers to a conception of being human and living in a constructed human culture (Kansanen, 2002). Didaktiks is centered on expectations concerning the tasks of the teacher working in a context that is defined by two sources of authority: (1) Bildung (i.e., the relationship between the individual and the general) and (2) *Lehrplan* (i.e., the state-mandated curriculum) (Autio, 2006).

In Germany, Didaktiks and its components: the content, the learner, and the teacher are commonly presented in the form of a triangle, a tool to structure the field of Didaktik research and theory (Hopmann & Riquarts, 1995). Although the triangle is an abstract concept it is always situated in some context such as the Didaktiks of mathematics. In addition, educational philosophy is always embedded in Didaktiks and is an essential part of every area or subdiscipline (Kansanen, 2002).

According to Westbury (1998), Didaktiks is much more sensitive (as compared to U.S. conceptions of education) to personal variance among teachers, allowing them more intellectual and professional freedom to think and accomplish their tasks. In addition, for German teachers

> the state's curriculum making has not been seen as something which could or should explicitly direct teaching, but rather as an authoritative selection of traditions that must become embedded, for realization in the classroom, in the self-determined work of teachers and in the forms of teacher thinking represented by Didaktik. (Westbury, 1998, p. 48)

In other words, teachers are expected to have their own teaching philosophies and make their own decisions about implementing them; to have Didaktiks of their own (Kansanen, 2003).

Finally, to allow each student to reach his or her full potential, three basic levels of secondary schools are available for students with differing ability. These different aspects of the philosophical stance of German schools could very well have a major impact on teachers' and students' personal epistemology and the epistemic climate in general.

U.S. Educational Philosophy. Although there is much debate on the best approach to education in the U.S. and reform efforts abound, there are clear links to traditional philosophy and philosophies of education that would characterize the U.S. approach to education. There are two major principles that undergrid the educational orientation of the U.S.: (1) preeminence of the individual, and 2) rational thought and respect for objective science and the scientific method (Kauchak et al., 2002). In addition, "part of the American dream is the 'common school' an institution that would serve all the children of all the people. Although that ideal has not been reached completely, it comes close to being realized in the elementary school" (Jarolimek, Foster, & Kellough, 2005, p. 4).

It has been argued that the works of John Dewey (1859–1952) have had more impact on U.S. education than any other body of literature (Kauchak, Eggen, & Carter, 2002; Westbury, 1998). Dewey viewed education as a process for improving the human condition. In terms of traditional schools of philosophy Dewey's work can be traced back to *Pragmatism* (also referred to as *Experimentalism*). Briefly, this view holds that there are no absolute truths; instead "truth is what works, hence the term" (Kauchak, et al., 2002, p. 188). For pragmatists, experience is a key idea and truth represents the interaction between the individual and the environment. Truth is considered to be personal and relative.

U.S. reform efforts of the last 20 years (e.g., *A Nation at Risk,* Back to Basics Curriculum, and the *No Child Left Behind Act*) can be linked to the educational philosophy of *Essentialism* (McClaslin & Good, 1996; Ornstein & Hunkins, 2004). This perspective holds that there is a critical core of information that exists that all people should possess. In educational terms, there is a set of knowledge and skills that teachers must possess to be effective educators and students must possess to maximize their own learning. An additional educational philosophy that has been influential in U.S. education is that of *Progressivism* which emphasizes curriculum that focuses on real-world problem-solving and individual development. Examples of Progressivism's influence (with links back to Pragmatism) include Dewey's views of participatory democratic education, the constructivist view of learning, and learner-centered curricula that are prevalent in U.S. colleges of education and elementary schools (Lambert & McCombs, 1998; Ornstein & Hunkins, 2004).

In terms of teacher education, educational philosophy does not seem to be an area that is stressed. The gap between theory and practice, for example, remains an important issue (e.g., Bloom, 1975; Shapiro & Kilbey, 1990). Some claim that philosophical ideas about education have no practical significance for the specific situations in which practitioners are working in. Although there are movements toward advocating for the importance of educational philosophy in teacher decision-making, for example, the reliance on the explicit understanding of educational philosophy or the development of a personal educational philosophy is not widespread in teacher education, rather there is a focus on ensuring student success through empirically based teaching practices (Heslep, 1997).

Rather than a more personal philosophy of teaching, a general set of teacher knowledge and skills is stressed for teachers to possess to help facilitate student learning (Jarolimek & Foster, 1985). These research-based guidelines include skills such as classroom management, lesson preparation, setting objectives, using various modes of teaching, selecting and implementing learning activities, and evaluating student learning (Brophy & Good, 1986).

In his critical analysis of U.S. education (as compared to German Didaktiks), Westbury (1998) states that according to U.S. educational philosophy or curriculum studies, the work of the teacher is

> explicitly directed by an authoritative agency which has (*sic*) as part of its larger program a curriculum containing both statements of aims, prescribed content (and in the American case, textbooks), and methods of teaching which teachers are expected to "implement." (p. 48)

In addition, teachers are more strictly controlled by educational administrators and by the expertise of scholars and scientists. Again, these different philosophical underpinnings, we hypothesize, have important influences in the personal epistemology of teachers and students and of the more general epistemic climate of elementary classrooms.

7.2.3 Practical Similarities and Differences

In the following section, we examine the more practical similarities and differences in German and U.S. elementary schools in terms of: students, teachers, curriculum, instructional approaches, and other miscellaneous aspects of the elementary education context. These descriptions are not intended to be exhaustive but are provided to give an overall picture of the more important practical similarities and differences between German and U.S. elementary schools.

U.S. and German Elementary Education. Elementary school education is compulsory in the U.S. and Germany. Around 6 years of age children are enrolled into elementary schools and placed in classes of 18–30 students with one teacher; this teacher, who is typically female, may be assisted in various degrees by teachers specialized in certain school subjects, such as art, music, and physical education, and/or special needs education, such as learning and behavior difficulties (Ashwill, 1999; Kauchak, et al., 2002). Grading in elementary schools is generally criterion-referenced and consists of developmental checklists and narratives until children are in at least third grade and then numerical marks/letter grades become more prevalent (Lake & Kafka, 1996). Children progress through advancing classes until they complete their elementary education. During this time they commonly stay in their class communities.

Typically, elementary schools are neighborhood-based and they take place in self-contained buildings. They are organized in, and administratively overseen by, school districts that answer to their state department of education. In Germany and the U.S. each state has the exclusive right to determine its education (e.g., educational standards and administration), and is accountable for its successful implementation. In this undertaking the states are financially supported and provided with educational recommendations by their federal governments (Ashwill, 1999; Kauchak, et al., 2002).

German Elementary Education. The German educational system provides different paths for students based on individual ability. Children enter the *Grundschule* (i.e., elementary school) at age 6 and remain together through fourth grade. Looping, or students remaining with their same teacher across two or more grade levels, is a common practice. Following elementary school and based on continuous and regularized assessment (Downing & Andrea, 1996; Phillips, 2001), teacher recommendations, and the parent's final say, students are then placed in different school forms. Although changes within the system are taking place and there are regional differences, the traditional three-tiered system of education remains intact (Ashwill, 1999). In most states children enter one of the several school forms at the lower secondary level:

Hauptschule (tier 1; grades 5–9; low ability) which fulfills the states minimum requirements and prepares students for subsequent vocational/trades apprenticeship programs (e.g., butcher, carpenter, hairstylist, etc.).

Realschule (tier 2; grades 5–10; medium ability) which prepares students for career apprenticeships and requires more language, math skills, and one foreign language (e.g., bank tellers, electricians, sales clerks, etc.).

Gymnasium (tier 3; grades 5–12; high ability) which includes college and white-collar preparation programs with specialized programs such as math and physical sciences, languages, arts, and music. Commonly, the acquisition of one or two foreign languages is required. Students select the appropriate gymnasium based on their career interest (e.g., physician, scientist, lawyer, teacher, etc.).

Gesamtschule (grades 5–12) are comprehensive schools, similar to U.S. public schools that include all abilities levels. These schools are attended by a small number of students and are commonly found in states that are governed by the Social Democratic Party of Germany.

Sonderschule is designed as a school to accommodate the educational needs of students with impairments and disabilities. The special education system is administratively separated from the other school forms (Ashwill, 1999; Noack, 1999).

Generally, students are more homogeneous in terms of their socioeconomic status, ethnicity, and ability levels. They attend a relatively short school day, 12 months out of the year (with short breaks throughout) and student violence and weapons are virtually unheard of (Ashwill, 1999). School for students revolves around academic activities with few opportunities for social interaction (Noak, 1999).

The same grading scale is used throughout the German education system and it uses a 6-point scale (1 = very good, 2 = good, 3 = satisfactory, 4 = adequate, 5 = poor, 6 = very poor). Classroom exams and report cards are also standardized across the states (Ashwill, 1999). Teachers follow a state-mandated curriculum (i e., Lehrplan). Curriculum is continuously sequenced (e.g., grade 5 math to grade 12 math). Although there is separation of church and state by law, in Germany, there are still close traditional links between the educational system and the churches. Religion is a regular school subject with students free to participate or not (Fuhr, 1997). Foreign language instruction, especially English, is very prevalent.

Teacher education for all school types consists of 4–5 academic years of training at a university (first state exam administered) followed by 2 years of employment as an apprentice teacher under the continuous tutelage of a mentor teacher (second state exam administered) (Ashwill, 1999; Noack, 1999). "Teachers in Germany are relatively better paid and respected than their American colleagues. A recent poll ranked teachers second behind judges on the 'most-respected' list of professionals" (Noak, 1999, p. 774). Teachers are viewed as civil servants with tenure. The teaching profession maintains its own professional hierarchy which is similar to other professional guilds and that of higher education in the U.S. (Noack, 1999).

The concept of full-time administrators is alien to most German educators. Master teachers (i.e., those who teach for several years, pass the third state exam, and receive nominations from other master teachers) take on the role of "principal" and have full responsibility for teacher training, curriculum development, and selection of instructional materials. These master teachers in principal/leadership positions must still be active teachers and they seldom observe or evaluate practicing teachers (Noack, 1999). Additional staff such as school counselors and nurses does not exist.

U.S. Elementary Education. In the U.S., public schools have taken on many functions beyond reading, writing, and arithmetic. Some of the additional functions include: (1) a "melting-pot socialization" in which a blending of diverse ethnicities and cultures is attempted, (2) recreation and avocation (i.e., extracurricular clubs and sports), (3) special education (i.e., institutional care with extremely small staff/student ratios), (4) health and safety education (e.g., drug education, driver's education), and (5) food service and student transportation. None of these programs or services is provided in German schools (Noack, 1999). Along with extracurricular activities social interaction is generally encouraged among students.

Students in U.S. public schools are quite diverse in terms of their socioeconomic status, ethnicity, and learning ability. In general, there are three main levels of public schools in the U.S.: (1) elementary school (grades K–5), middle school (grades 6–8), and high school (grades 9–12). For the most part, all abilities levels are represented in each school with certain classes separated at the secondary level based on ability (e.g., advanced placement, remedial, and general classes). Inclusion by law is also an important aspect of many public schools. Poverty and "at-risk" students (i.e., those students who are in danger of failing to complete their education with the skills necessary to survive in modern society) is a pervasive issue in U.S. schools (Slavin, Karweit, & Madden, 1989).

Curriculum and standards in the U.S. are heavily influenced by federal, state, and district entities. A continuous model of curricula or curricula sequenced in parts (e.g., algebra/geometry/calculus) is the norm in U.S. Schools (Downing & Andrea, 1996). Secular education leaves religious education for outside of school (Greenawalt, 2005). Although there are proponents for it, looping does not occur in general (Little & Little, 2001).

Teacher education generally consists of 4 years of university training (this includes 1 year of student teaching). It is currently debated whether or not teachers should be viewed as true "professionals." Reasons against this include the perception that: (1) teacher education admission requirements are low, (2) coursework for professional education is low, and (3) teachers lack professional autonomy. In fact, in a text written for beginning teachers it states that because of standards-based education, high-stakes testing, and teacher accountability, new teachers should expect "less autonomy than teachers had 10 years or even 5 years ago" (Kauchak, et al., 2002, p. 28).

Principals have a significant amount of control over the public schools in the U.S.. In general, they are usually appointed by a school board, make executive decisions that govern the school, have authority over employment of teachers, and are the chief disciplinarian of students (e.g., Wilmore, 2004). Additional staff such as school counselors, school psychologists, and nurses is available to students.

In summary, both similarities and differences can be found in the German and U.S. elementary school system. Philosophically, both countries share the idea to ensure the continuity of their society through their educational systems. Social justice and academic equality are important aims of both systems. Philosophical differences are reflected in their educational approaches. German teachers are recommended to base decisions regarding their own classroom teaching on their personal teaching philosophies, while U.S. teachers are encouraged to rely more on externally recommended, research-based approaches. Although the practical differences can be identified across both school systems, at the elementary school level, they share many similarities. Differences can be identified in the training of elementary school teachers. U.S. and German teachers receive their academic training in approximately four years; but in Germany teachers, however, need to complete an additional practical training for 2 years. As can be seen, there are interesting and important similarities and differences in German and U.S. elementary schools. Differences in German and U.S. approaches to research are also important to consider and are the focus of the next section.

7.3 German Didactics and U.S. Educational Psychology Approaches to Research

The area of *didactics* is a direct translation from the German philosophical approach to education Didaktiks (described previously). This term is similar in meaning to the concept of Didaktiks but centers on a method of educational research. Didactics, or the systematic study of the teaching–studying–learning process has a long tradition in many European countries. In contrast, in the North American research literature didactics is “largely absent” (Kansanen, 2002, p. 427). It has been proposed that the U.S. tradition of educational psychology research can gain from didactics in terms of offering a more holistic and relevant view of educational research.

Didactics as a research framework considers the processes among teachers and their instruction and students and their learning as part of a whole, rather than studying each aspect individually (as is done in most educational psychology research in the U.S.). In addition, didactics brings to educational psychology research the need to examine the educational philosophy behind all that is done. “Philosophical contemplation is an essential part of German didactics” and “belongs at the heart of any critical conception of better education” (Kansanen, 2002, p. 433).

In the spirit of these sentiments a model for research in personal epistemology is described that attempts to fuse the foundations of didactics (i.e., considering the teaching–studying–learning process more as a whole) and U.S. educational psychology (i.e., research and theory on personal epistemology and its implications for learning and instruction). This model can provide a means to carry out cross-cultural research in personal epistemology and offer important implications for future research and education.

7.3.1 The Educational Model of Personal Epistemology

The Educational Model of Personal Epistemology (*EMPE*), proposed by Haerle (2006), is partially based on empirical research but also draws from theoretical models in the fields of personal epistemology (Bendixen & Rule, 2004; Hofer, 2001) and German Didaktiks (Hiller, 1976; Kattmann, Duit, Gropengiesser, & Komorek, 1996; Westphal, 1990, 2002). It is conceptualized (a) to describe the epistemic climate of elementary classrooms stemming from different epistemic components (i.e., learners' personal epistemology, teacher's personal epistemology, epistemic knowledge representations, and epistemic instruction) and their reciprocal relations and (b) to demonstrate how these components and interrelations may be taken into account to enhance personal epistemology in educational contexts.

The *EMPE* encompasses four different components (see Fig. 7.1). These include *learners' personal epistemology* (i.e., learners' conceptions about knowledge and knowing), *teachers' personal epistemology* (i.e., teachers' conceptions about knowledge and knowing), *epistemic knowledge representations* (i.e., epistemological assumptions that underlie educational knowledge representations, such as curricula and school books), and *epistemic instruction* (i.e., epistemological assumptions that underlie instruction). Some of these components have been partially acknowledged in other models (Bendixen & Rule, 2004; Hiller, 1976; Hofer, 2001; Kattmann et al., 1996; Westphal, 1990, 2002), however, this model contributes to the understanding of personal epistemology for the following reasons. First, these components have not yet been integrated in this particular way; that is, the *epistemic knowledge representations* component is not accounted for in other personal epistemology models and the *teachers' personal epistemology* component is not considered in the didaktikal models. Second, these components

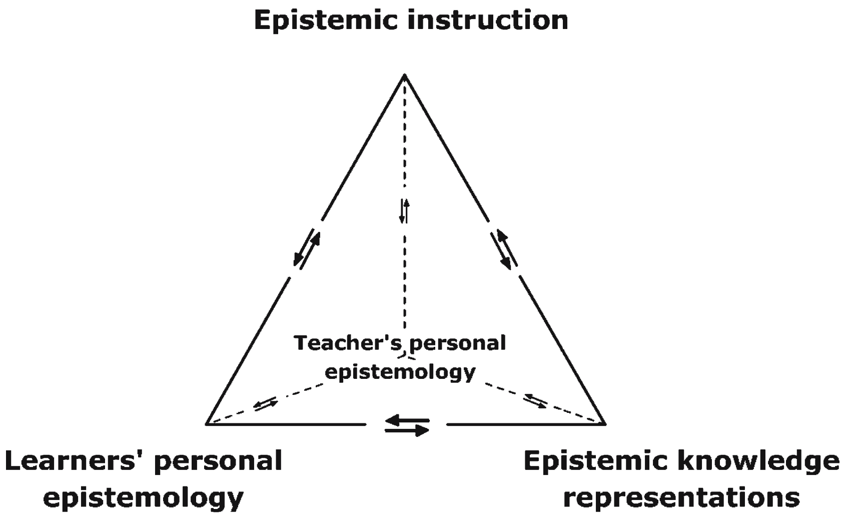


Fig. 7.1 The *Educational Model of Personal Epistemology* (Haerle, 2006)

specifically focus on epistemological aspects of education, which represent a new perspective in personal epistemology research. Third, as all four components are reciprocally connected, this educational model has the potential to describe the epistemic climate of classrooms. In summary, this model allows for a more holistic approach to cross-cultural research on personal epistemology in elementary classrooms. The four components and their interrelations are depicted in Fig. 7.1 and are subsequently described.

Learners' Personal Epistemology. The component *learners' personal epistemology* is defined as a set of conceptions about knowledge and knowing that encompasses all four of the epistemological dimensions previously discussed in our definition: (1) *certainty of knowledge*, (2) *simplicity of knowledge*, (3) *justification of knowledge*, and (4) *source of knowledge* (Hofer & Pintrich, 1997). This component is acknowledged in personal epistemology research and found in all models that are incorporated into the *EMPE*. In the field of personal epistemology most of the research studies focus on the investigation of the epistemic conceptions of individuals, in particular of learners, to better understand their influence on the process of learning (e.g., Windschitl & Andre, 1998; Bendixen, et al., 1998). Very few studies have investigated the personal epistemology of learners in elementary schools (e.g., Haerle, 2006; Kuhn, Cheny, & Weinstock, 2000). In the didaktikal models this component can be identified but is not necessarily central. *Learners' personal epistemology* is one aspect in the models of Westphal (1990) and Kattmann et al. (1996). In Hiller's Konstruktive Didaktik (1976) learners' worldviews are fundamental; but they are only recognized as a collective, societal epistemology.

Teachers' Personal Epistemology. The component *teachers' personal epistemology* is also defined as a set of personal theories about knowledge and knowing and contains all four of the epistemological dimensions (see previous component; Hofer & Pintrich, 1997). It is an important component in this model as teachers are in charge of everyday classroom teaching. The component *teachers' personal epistemology* is acknowledged in personal epistemology research and found in some of the newer models. For example, some researchers have investigated the personal epistemology of teachers and have found inconsistencies in teachers' epistemological beliefs and their classroom practices (e.g., Kane, Sandretto, & Health, 2002; Schraw & Olafson, 2002). *Teachers' personal epistemology* is also recognized in the theoretical models of Bendixen and Rule (2004) and Hofer (2001). In the didaktikal models this component is only briefly mentioned by Kattmann et al. (1996).

Epistemic Knowledge Representations. The component *epistemic knowledge representations* describes epistemological assumptions that are reflected in all forms of knowledge (e.g., school books and curricula). It also contains all four of the epistemological dimensions (see first component; Hofer & Pintrich, 1997). This component is in some aspects acknowledged in personal epistemology research and found in most of its models (e.g., Diakidoy, Kendeou, & Ioannides, 2002; Hofer, 2002). Different aspects of *epistemic knowledge representations* are also identifiable in the didaktikal models. Kattmann et al. (1996) mention that the epistemological assumptions embedded in scientific and everyday conceptions are an essential part of conceptual change and, therefore, should be accounted for in the development of instruction. Westphal (1990) accounts for epistemological structures in the knowledge representations of curricula and calls for their consideration when implementing instruction. Hiller (1976) criticizes the prescription of educational knowledge representations in curricula as a form of dogmatism (i.e., a system of ideas based on insufficiently examined premises/opinions).

Epistemic Instruction. The component *epistemic instruction* describes epistemological assumptions that underlie instruction (e.g., teaching strategies and educational classroom approaches). *Epistemic instruction* contains all four of the epistemological dimensions (see first component; Hofer & Pintrich, 1997). In the field of personal epistemology few empirical studies examine the impact of epistemic instruction on the personal epistemology of elementary school students. Two exploratory studies argue that epistemological metaphors (Louca, Elby, Hammer, & Kagey, 2004) and socio-constructivist approaches in math education (Steinbring, 1991) might influence learners' personal epistemology, while interventions studies provide evidence that constructivist teaching approaches may advance young learners' epistemology (Boscolo & Mason, 2001; Smith, Maclin, Houghton, & Hennessey, 2000). The didaktikal models stress the impact of *epistemic instruction* on learners' personal epistemology. Kattmann et al. (1996) and Westphal (1990) propose to use instruction to enhance personal epistemology in learners.

Reciprocal Relations. In the *EMPE* all four components are reciprocally related and account for the dynamic nature of epistemic climate (see Fig. 7.1). These relations have been partially addressed in the field of personal epistemology and the didaktikal models. Personal epistemology research has identified that *learners' personal epistemology* can be impacted by *teacher's personal epistemology* (e.g., Bendixen, 2002; Haerle, 2006, Hofer, 2004b; Schraw & Olafson, 2002), *epistemic knowledge representations* (e.g., Diakidoy et al., 2003; Haerle, 2006), and various forms of *epistemic instruction* (e.g., Boscolo & Mason, 2001; Steinbring, 1991). Hofer (2001) describes also the indirect impact of *teacher's personal epistemology* on students via their choice of *instruction* (c.f., Johnston, Woodside-Jiron, & Day, 2001; Schraw & Olafson, 2002). Bendixen and Rule (2004) stress the reciprocal nature of the relation between the *personal epistemology of learners, teachers*, peers and parents. In the didaktikal models *learners' personal epistemology* can be influenced by *teacher's personal epistemology*, *epistemic knowledge presentations*, and *epistemic instruction* (Hiller, 1976; Kattmann et al., 1996; Westphal, 1990). Kattmann et al. (1996) and Westphal (1990) also describe the relation between the components as reciprocal. It is only the *EMPE* that describes all four epistemic components as being connected in reciprocal ways.

In summary, the *EMPE* theorizes four components and their reciprocal interrelations to account for epistemic climate in the classroom. The components allow educators and researchers to pinpoint various aspects of personal epistemology in educational settings. As all components of the *EMPE* encompass the four epistemological dimensions, the model provides a research framework for in-depth analyses of each component and their reciprocal relations. Furthermore, it provides a conceptual framework for a more detailed and holistic comparison of personal epistemology in German and U.S. elementary classrooms.

7.3.2 Epistemic Climate in German and U.S. Elementary Classrooms

In the following section, we discuss our expectations for differences and similarities in epistemic climate in the U.S. and Germany. This cultural comparison is based on our previous discussion of philosophical differences and similarities, it considers all four of the epistemological dimensions (see our previous definition; Hofer & Pintrich, 1997) and accounts for the epistemic components of the *EMPE* (see Table 7.1).

Differences in German and U.S. Epistemic Climate. Knowledge in German elementary classrooms may be portrayed as more subjective and uncertain. That is, teachers are viewed as professionals with autonomy who base the selection of instructional approaches on their personal teaching philosophies (e.g., Jank & Meyer, 2002; Meyer & Vogt, 1997). This autonomy may influence a teacher's personal epistemology and might allow for a more subjective (i.e., based on intuition and personal experiences) and diverse presentation of knowledge within and across classrooms (e.g., Westbury, 1998). Although learners might be more exposed to more subjective and uncertain knowledge, their personal epistemology might be less diverse as German society appears to be more homogeneous than U.S. society. In addition, it can be assumed that the homogeneity of learners' personal epistemology may increase in classrooms as students enter the three-tiered system after completing elementary school (i.e., Hauptschule, Realschule, and Gymnasium).

Furthermore, due to the fact that Didaktiks is subject-specific, knowledge might be presented in more of a domain-specific nature (e.g., Kattmann, et al., 1996). For example, a basic concept in mathematics may be taught differently than a basic concept in social science. Knowledge might also be viewed by learners and teachers as more complex as in the teaching–learning–studying process of Didaktiks (Kansanen, 2002), and that the knowledge of learners, teachers, and school subjects

Table 7.1 Potential epistemological dimensions of epistemic climate in German and U.S. elementary classrooms

Educational approach / Personal epistemology	Didaktiks in German elementary classrooms	Research-based approaches in U.S. elementary classrooms
Certainty of knowledge	More uncertain, subjective, and context/domain specific	More certain, objective, and context/domain general
Simplicity of knowledge	More complex	More simple
Justification of knowledge	(1) Teaching philosophy of expert teacher (2) General educational philosophy shared by culture (3) More applied research	(1) More foundational research by scientists and experts (not teachers) (2) General educational philosophy shared by culture
Source of knowledge	More internal and external sources	More external sources

are constantly and reciprocally interrelated (Hopmann & Riquarts, 1995; Kattmann, et al., 1996).

Finally, as German teachers are trained to rely on their personal philosophies in their teaching approaches, their judgments may be based more on internal sources, such as intuition and personal experiences (e.g., Westbury, 1998). As research plays only a minor role in informing elementary education, it would seem likely that teachers would depend more on internal sources. Less focus on foundational research and the dependency on more subjective sources might cause a more narrowed view regarding the justification and source of knowledge within classrooms.

The epistemic climate in U.S. elementary classrooms may differ from German classrooms in that knowledge may be presented from a more certain and objective perspective. Teachers are encouraged to implement more research-based teaching approaches that can be applied across different school subjects (e.g., Brophy & Good, 1986; Kauchak, et al., 2002). This domain-general presentation of knowledge may be viewed as more objective and certain and, therefore, less significantly influenced by the teacher's own personal epistemology.

Furthermore, knowledge in U.S. classrooms might be perceived as more simplistic in nature. This might be particularly true as, for example, knowledge about the learner, teachers, and school subjects is often researched and theorized in separation from the other (e.g., Berliner, 1991; Eisner, 2002) and not integrated when accounting for classroom learning and instuction (e.g., Kansanen, 2002, 2003). The cultural expectations of what makes a successful teacher or student are limited to a certain set of knowledge and skills (e.g., Eisner, 2002). Therefore, knowledge in U.S. epistemic climates might be more likely to be presented in the form of discreet facts rather than interconnected concepts.

Finally, in U.S. elementary classrooms knowledge on how to teach is primarily justified by external scientists and scholars (e.g., Kauchak, et al., 2002). There is debate on whether U.S. elementary teachers are viewed as professionals with autonomy and they are not expected to base their teaching approach on a personal teaching philosophy (e.g., Eisner, 2002; Kansanen, 2002). The lack of subjective knowledge and the dependency on more external sources might cause a more narrowed view regarding the justification and source of knowledge within epistemic climates (e.g., Kauchak, et al., 2002). Other external sources for knowledge justification, such as curricula standards, are similar to those in German classrooms and are discussed in the following section.

Similarities in German and U.S. Epistemic Climate. The most clearest similarity between epistemic climates in German and U.S. elementary education is the determination of what knowledge should be taught in which school subject. Knowledge representations, such as curricula and school books, are externally mandated by schools districts and/or state departments of education (e.g., Autio, 2006; Kauchak, et al., 2002; Westbury, 1998), which claim the role of an educational authority. Because this process of justification and its sources are out of the realm of classroom teachers, knowledge might be perceived in the epistemic climate of both countries as certain and simple. The general justification of the selected subject knowledge is based on the aim to maintain German and U.S. cultures, respectively (e.g., Gudions, 1994; Purves, 1988). It is also grounded in the shared educational philosophy to account for sociocultural, academic equality, and social justice and to guide children toward good citizenship (e.g., Whitebread, 2000).

In both cultures, the learner could also be considered as an internal source of knowledge in classrooms. Based on the child-centered teaching philosophy shared by Germany and the U.S., the learner's (prior) knowledge should be taken into account in classroom teaching (e.g., Lambert & McCombs, 1998; Jank & Meyer, 2002; Ornstein & Huskins, 2004). To "give students an opportunity to pose questions and to entertain alternative perspectives on what to study" (Eisner, 2002, p. 380), would mean to partially override the state departments' educational authority. This would account for more subjective and diverse knowledge in addition to mainstreamed knowledge in state-mandated curricula and text books. Furthermore, the increased diversity and subjectivity of knowledge claims might increase the conceptions of learners and teachers that the nature of knowledge and knowing is more uncertain, complex, and context-specific (e.g., Eisner, 2002; Knefelkamp, 1999; Perry 1970).

On the other side, the increasing "assessment culture" in both countries (e.g., Eisner, 2002; Ornstein & Hunkins, 2004), might supersede this philosophy and promote and understanding of knowledge as objective and factual. Because of the prescribed knowledge representations and its assessment focus education is often answer-oriented. Eisner refers to this phenomenon as "teachers have the questions, and students are to have the answers" (2002, p. 379). Based on this right and wrong culture knowledge may be viewed by students and teachers as certain and simple.

In summary, the philosophical and practical differences in the educational context of U.S. and Germany might impact epistemic climate distinctively, while shared aspects might also be identifiable as similarities in the elementary classrooms of both countries. Both, the similarities and differences bring forth important issues to be considered in education and research.

7.4 Implications for Education and Future Research

The goal of this chapter is to compare and contrast personal epistemology within the context of German and U.S. elementary schools. Important and interesting philosophical and practical differences were exposed. A model of epistemic climate was presented to enable cross-cultural research on personal epistemology to be conducted in a more holistic way. Within the context of the *EMPE*, our expectations for epistemological similarities and differences in these two Western cultures were then considered in terms of current theory and research. At this point, we are brought to the question that encompasses much of this chapter: What is the value of doing cross-cultural research in personal epistemology?

For the concluding section we would like to bring together what we consider to be the central value of cross-cultural work in the area of personal epistemology and, herein, focus on what both cultures share in terms of their goals for elementary education. To raise contributing citizens and to provide an appreciation/understanding for democracy are two central goals of both educational systems and these are also shared in most Western cultures (e.g., Jank & Meyer, 2002; Whitebread, 2000). Therefore, we propose that fostering evaluativistic thinking in students' personal epistemology should be a main goal starting in elementary education to ensure students' future roles as productive citizens. Evaluativistic thinking describes a way of knowing that focuses on evaluation and decision-making among differing viewpoints. In the developmental frameworks in the field of personal epistemology this is often defined as evaluativism – the most advanced level of epistemic development (Hofer & Pintrich, 1997; King & Kitchener, 1994; Kuhn et al., 2000).[1] Because evaluativistic thinking integrates subjective and objectives views of knowledge and considers its complexity and uncertainty in relation to its context (Kuhn & Weinstock, 2002), we argue that this form of thinking is most evocative for, and expressive of, the idea of democracy and what makes a "good" citizen in Western cultures. Therefore, we propose that evaluativistic thinking can and should be fostered in epistemic climates of elementary classrooms and can be considered within the context of the four epistemological dimensions of personal epistemology (see our previous definition; Bendixen & Haerle, 2004, 2005). For instance, evaluativistic thinkers view knowledge as uncertain and complex. They also evaluate knowledge based on logic and evidence and consider knowledge to exist both internally and externally.

In our view, elementary education is where U.S. and German cultures are most alike; more than at any other level of schooling. Much can be learned from focusing on these similarities and how each culture can gain from the strengths of the other. This is the purpose of comparative research and education (Noah, 1985). Cross-cultural comparisons of epistemic climate can shed light on the role educational systems, processes, or outcomes in the development of evaluativistic thinking can play in elementary school students. It allows for the exploration of potential relationships among education, educational philosophies, and society. Furthermore, cross-cultural research in personal epistemology provides a tool to inform and develop educational institutions and practices that encourage advanced personal epistemologies including fostering evaluativistic thinking.

7.4.1 Epistemic Climate and Culture

What is the value of understanding epistemic climate for cross-cultural research in personal epistemology? The *EMPE* was operationalized to demonstrate how different epistemic components (i.e., learners' and teacher's personal epistemology, epistemic knowledge representations, and epistemic instruction) and their

[1] In earlier developmental levels of epistemic development, individuals view knowledge as more objective, simple, and dichotomous (i.e., absolutism) or perceive knowledge as increasingly subjective, complex, and relativistic (i.e. multiplism) (Hofer & Pintrich, 1997; King & Kitchener, 1994; Kuhn et al., 2000).

reciprocal relations can contribute to the understanding of epistemic climate in elementary classrooms in the U.S. and Germany. As was discussed, the model focuses on the potential for researching the student–teacher–learning process (i.e., didactics; Kansanen, 2002). To our knowledge, very little research in personal epistemology is applied and/or more process-oriented. In recent years several scholars have called for a more mixed-method approach to research in this area to capture its complexities (e.g., Bendixen & Rule, 2004; Pintrich, 2002; Schraw, 2001). We concur with these recommendations, especially in terms of epistemic climate with its reciprocal dynamics and cross-cultural research. For example, research using newer techniques such as think-alouds (Hofer, 2004a), concept mapping (Haerle, 2006), and various modes of teacher vignettes (Schraw & Olafson, 2002) would be useful especially when we begin to extend our research to more complex phenomena, such as the reciprocal relation between learners' and teacher's personal epistemology. With the goal of capturing more of the classroom culture and its ongoing processes, classroom observations, document analysis of school books and curricula (e.g., Kattman et al., 1996; Wineburg, 1991), and ethnographies would seem extremely beneficial.

To successfully investigate classroom culture and processes, there is the need for researchers to acquire a diverse repertoire of methodological skills and broad background knowledge in education. Berliner (1991) provided suggestions that fall into place with our understanding of how personal epistemology should be empirically approached in elementary classrooms. Researchers should be "technologically sophisticated and able to conduct instructional research in complex group settings" (Berliner, 1991, p. 149). They need to be more conversant "in small sample, qualitative designs, and methods of cognitive psychology, than in large sample, quantitative, true experimental design" (p. 150). Consistent with our discussion of didactics, researchers should also have a more holistic understanding of elementary education. This understanding includes knowledge about the learning of students and teachers, the development of their conceptions and beliefs in areas such as teaching methods, learning strategies, and content knowledge. Furthermore, they should also have a foundation in the content knowledge of the school subject in which their classroom research is contextualized. When conducting cross-cultural classroom research, we also suggest that this endeavor requires researchers who are sensitive to cultural differences and similarities in education and research.

We have proposed that culture is also a crucial aspect of epistemic climate. Because epistemological theories are socially constructed, it is assumed, from a Vygotskian perspective, that culture plays an important role in the development of epistemological beliefs and the nature of epistemic climates (Hofer & Pintrich, 1997; Pintrich, 2002; Qian & Pan, 2002; Vygotsky, 1978). In terms of *EMPE*, a systems approach could be embedded within it to allow for another layer of complexity, that of culture, to be considered. Systems theory (i.e., micro, meso, and macro levels of influence) has been used in other educational contexts (e.g., Bronfenbrenner, 1979) and, more recently, within the area of personal epistemology (Schommer-Aikins, 2004; Winsor, 2006). Similarly, the *EMPE* is situated at the micro level but can also be influenced by the meso and macro levels (see Fig. 7.2).

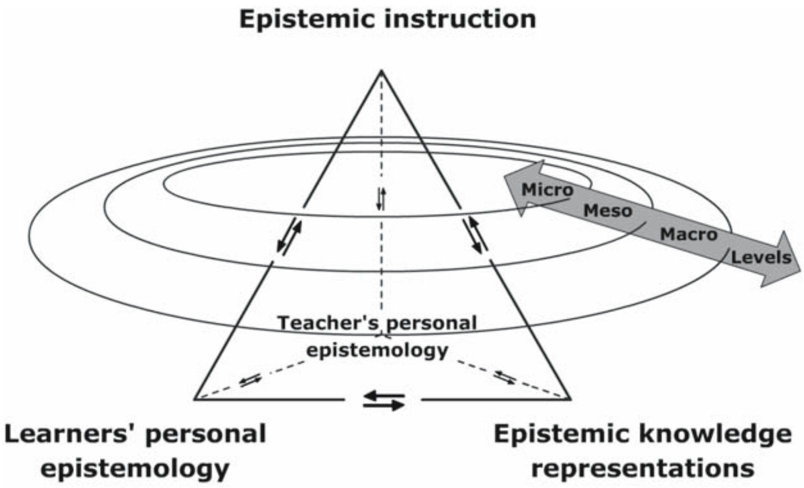


Fig. 7.2 A systemic approach to the *Educational Model of Personal Epistemology*

Epistemic climate can be culturally impacted from different systemic levels. The personal epistemology of a learner, for example, can be influenced on the micro level (i.e., individual level) by the epistemological underpinnings of the curriculum used in their classroom. Teacher training may impact the personal epistemology of teachers on the meso level (i.e., institutional level). Epistemic climate or its components can also be considered on the macro level (i.e., societal level) in the values shared by a society (e.g., educational philosophies). In other words, the components of the *EMPE* stand not only in relation to each other, but are also interrelated with entities outside the classroom on the meso level (e.g., parents, school, and [religious] community) and the macro level (e.g., departments of education, state and federal governments, and society). We propose that these relations, similar to those within the *EMPE*, are reciprocal in nature. For example, today's elementary school students (i.e., micro level) will be tomorrow's generation and determine, through their political decisions and elected governments (i.e., macro level), how their children will be educated in elementary classrooms (i.e., micro level).

Future research could attempt to examine the *EMPE* model within the context of a systems approach as well. The various roles of individuals and entities outside of those specified in *EMPE* (i.e., learners, teachers, instruction, and knowledge representations) could be examined. For example, future research could investigate the roles of peers, parents, administrators, scholars, and policymakers in the epistemic climate of elementary classrooms.

In summary, the value of using *EMPE* to guide cross-cultural theory and research in personal epistemology is that it may provide a richer understanding of epistemic climate and how it can foster advanced epistemological thinking in students in German and U.S. cultures. As we have stated there are many roles within the epistemic climate of elementary classrooms. In the following section we consider the educational implications stemming from one of the most influential players in epistemic climate; the elementary teacher.

7.4.2 The Teacher

What is the value in understanding the influence of the teacher in the epistemic climate of elementary classrooms? Within the field of personal epistemology, a growing body of research does exist that examines teachers' personal epistemology (e.g., Brownlee et al., 2001; Schraw & Olafson, 2002). Based on this research and our understanding of epistemic climate in elementary classrooms we propose that teachers can and should be key persons in fostering evaluativistic thinking in children. To succeed in this endeavor, we suggest that teachers, along with their use of appropriate educational materials and instruction, should be evaluativistic thinkers themselves. How can evaluativistic thinking be fostered in teachers? Research has shown that teachers' personal theories can be influenced during their academic training (e.g., Brownlee et al., 2001) and are subject to change over the years of their practical experiences (e.g., Tsai, 2002; White, 2001). Pre- and in-service teacher training, therefore, can make an important impact on the advancement of teachers' personal epistemology toward evaluativism.

Previously, we have provided two different pictures of German and U.S. elementary school teachers and their training. As we pointed out, German teachers seem to be more clearly viewed as professionals as compared to their U.S. counterparts. Consistent with the educational philosophy of Didaktiks, they are trained in an apprenticeship model with two additional years of practical training (e.g., Jank & Meyer, 2002; Noack, 1999). This practical training is designed so that the apprentice teacher will have a chance to put their academic training and classroom experiences together to form their own philosophy before they are in charge of a classroom (Kansanen, 2003). Furthermore, they are viewed as true professionals with autonomy in their decision-making (Kauchak, et al., 2002). We are confident that extended teacher training and autonomy impact epistemic climate in elementary schools.

What are the educational implications of teachers being viewed as professionals for learners' personal epistemologies, epistemic climate, and teacher education? Does an apprenticeship model in training and more autonomous decision-making foster more evaluativistic thinking in teachers? Does more advanced epistemological thinking in teachers necessarily translate into more advanced thinking in their students? We think that future research should definitely examine these kinds of questions in both cultures. If the results show there is a positive link between teachers' epistemological beliefs and their students' beliefs, this may help influence the possibility of adopting more of an apprenticeship model in U.S. teacher education, which is what has been suggested by some educational scholars (e.g., Berliner, 1991; Eisner, 2002).

7.4.3 The Science and Art of Teaching

There are many parallels between the current chapter's consideration of teachers' personal epistemology in U.S. and German elementary schools and the broader discussion of whether teaching is an art or a science (Woolfolk, 2001). Some educators conceive of teaching as more of an art that requires imagination, skill, and intuition because teaching is such a dynamic activity situated in a complex and varied classroom environment. We see this reflected in the German Didaktik philosophy in that teachers are the decision-makers who rely on their own teaching philosophies and also the need to consider the broader teaching–studying–learning process (Kansanen, 2002) as well. In this case, teaching appears to be more of a subjective process of presenting knowledge and knowing on the basis of personal theories, experiences, and intuition.

On the other side, some consider teaching to be more of a science because it requires an understanding of effective educational methods (based on research) and school subjects and should be done in a more systematic way. The U.S. approach to education seems to be focused more on this side of teaching in that teachers are viewed as implementers of scientifically approved teaching methods and teaching programs (e.g., Westbury, 1998). Therefore, teaching appears to be more of an objective process of presenting knowledge and knowing guided by sources outside the actual classroom (e.g., research and educational authorities).

Finally, many propose that quality teaching integrates *both* of these views and that the art of teaching (i.e., the creative processes and skills) is found in the application of the science of teaching (i.e., researched-based techniques and discipline knowledge) (Woolfolk, 2001). We support this perspective and see the integration of teaching as an art and a science in the strengths of both U.S. and German approaches to education. We argue that the integration of more autonomous and subjective ways of teaching (i.e., the art) with more research-based and objective approaches (i.e., the science) is reflective of an evaluativistic understanding of instruction. We contend that this form of teaching is representative of the advanced level of epistemic development and, therefore, may promote evaluativistic thinking in the epistemic climate of elementary classrooms.

The integration of the art and science of teaching falls in line with Perry's (1970) theory and how classroom communities should be designed to be supportive of evaluativistic thinking. Evaluativistic thinking requires exposure to diversity and complexity in knowledge and knowing (e.g., Knefelkamp, 1999). We consider this integration as a desirable aspect of epistemic climate in Western cultures. Future research is needed to investigate how different forms of teacher training, pre- and in-service, can be supportive in the development of epistemic thinking in teachers and, therein, be influential in epistemic climates in elementary classrooms.

Analogous to Woolfolk's (2001) discussion of the art and science of teaching, Kansanen (2002) compares the research approaches of German didactics and U.S. educational psychology. As we proposed earlier, quality teaching consists of blending art and science and is reflective of evaluativism. Similarly, we view the integration of German didactics and U.S. educational psychology as providing a more holistic and scientifically based approach to cross-cultural classroom research. For example, researchers should examine various aspects of education, not in isolation, but within their interrelations and broader processes. Again, we see the *EMPE*'s approach to research as a fusion of German didactics and U.S. educational psychology. This would mean approaching research and theory on personal epistemology and its implications for learning and instruction within the teaching–studying–learning process; the art and science of personal epistemology research.

7.4.4 The Promise of Evaluativistic Thinking

In conclusion, we have illustrated how the *EMPE* can be utilized to describe different classroom components and how they can influence elementary school students' personal epistemology along four epistemological dimensions (see Fig. 7.1). The conceptual comparison of elementary education in the two Western cultures of Germany and the U.S. has demonstrated how cultural similarities and differences can inform our theories, research, and educational implications in the field of personal epistemology. Finally, we stress that evaluativistic thinking should be fostered in epistemic climates of elementary classrooms and consider its broader impact on, and implications for, Western societies.

Elementary schools in the U.S. and Germany both have developing good citizenship as a main goal. In most Western cultures contributing citizens need the ability to make informed decisions within a complex society and to appreciate the idea of democracy (e.g., Naegli, 2006; Pearl & Pryor, 2005). For example, the right to vote for a representative in the government requires the ability to evaluate the views and beliefs of candidates and/or parties before making an educated choice. Jury duty, which is reflective of the right to a fair trial for each citizen, requires the juror's abilities to make shared judgments about evidence which then leads to decisions about guilt and innocence. These examples and the current chapter exemplify the importance of evaluativistic thinking in a democratic society. In essence, we believe that this begins within the epistemic climate of elementary classrooms.

References

Ashwill, M. A. (1999). *The educational system in Germany: Case study findings*. Washington, DC: National Institute on Student Achievement, Curriculum, and Assessment (ERIC Document Reproduction Service No. ED430906).

Autio, T. (2006). *Subjectivity, curriculum, and society: Between and beyond the German Didaktik and Anglo-American curriculum studies*. Mahwah, NJ: Lawrence Earlbaum.

Baxter Magolda, M. B. (1992). *Knowing and reasoning in college: Gender-related patterns in students' intellectual development*. San Francisco, CA: Jossey-Bass.

Bendixen, L. D. (2002). A process model of epistemic belief change. In B. K. Hofer & P. R. Pintrich (Eds.), *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 191–208). Mahwah, NJ: Lawrence Erlbaum.

Bendixen, L. D., & Rule, D. C. (2004). An integrative approach to personal epistemology: A guiding model. *Educational Psychologist*, *39(1)*, 69–80.

Bendixen, L. D., Schraw, G., & Dunkle, M. E. (1998). Epistemic beliefs and moral reasoning. *The Journal of Psychology*, *13*, 187–200.

Bendixen, L. D., & Haerle, F. C. (2005, November). *An interactive measure of children's personal epistemology*. Working session conducted at the Southwest Consortium for Innovations in Psychology in Education (SCIPIE) Inaugural Conference, Las Vegas, NV.

Berliner, D. (1991). Educational psychology and pedagogical expertise: New findings and new opportunities for thinking about training. *Educational Psychologist*, *(26)2*, 145–155.

Bloom, M. (1975). *The paradox of helping: Introduction to the philosophy of scientific practice*. New York: Wiley.

Boscolo, P., & Mason, L. (2001). Writing to learn, writing to transfer. In P. Tynjala, L. Mson, & K. Lonka (Eds.), *Writing as a learning tool. Integrating theory and practice* (pp. 83–104). Dordrecht, The Netherlands: Kluwer.

Bronfenbrenner, U. (1979). *The ecology of human development*. Cambridge, MA: Harvard University Press.

Brophy, J. E., & Good, T. (1986). Teacher behavior and student assessment. In M. Wittrock (Ed.), *Handbook of research on teaching* (3rd edition, pp. 328–375). New York: Macmillan.

Brownlee, J., Purdie, N., & Boulton-Lewis, G. (2001). Changing epistemological beliefs in pre-service teacher education students. *Teaching in Higher Education*, *6(2)*, 247–268.

Chan, K. -W., & Elliott, R. G. (2004). Epistemological beliefs across cultures: Critique and analysis of beliefs structure studies. *Educational Psychology*, *(24)2*, 123–142.

Chan, K. -W., & Elliott, R. G. (2000). Exploratory study of epistemological beliefs of Hong Kong teacher education students: Resolving conceptual and empirical issues. *Asia-Pacific Journal of Teacher Education*, *28(3)*, 225–234.

Chandler, M., Boyes, M., & Ball. L. (1990). Relativism and stations of epistemic doubt. *Journal of Experimental Child Psychology*, *50*, 370–395.

Diakidoy, I. N., Kendeou, P., & Ioannides, C. (2003). Reading about energy: The effect of text structure in science learning and conceptual change. *Contemporary Educational Psychology*, 28, 335–356.

Downing, J., & D'Andrea, L. M. (1996). What American elementary school counselors can learn from European educational systems. *Elementary School Guidance & Counseling*, *31(2)*, 114–21.

Eisner, E. (2002). The kind of schools we need. *Phi Delta Kappan*, *(83)8*, 376–383.

Fuhr, C. (1997). *The German education system since 1945: Outlines and problems* (ERIC Document Reproduction Service No. ED428000).

Greenawalt, K. (2005). *Does God belong in public schools?* Princeton, NY: Princeton University Press.

Gudions, H. (1994). *Pädagogisches Grundwissen [Pedagogical basic knowledge.]*. Bad Heilbrunn: Klinkhardt.

Gundem, B., & Hopmann, S. (Eds.) (1998) *Didaktik and/or curriculum: An international dialogue*. New York: Peter Lang.

Haerle, F. C. (2006). *Personal epistemology of fourth graders: Their beliefs about knowledge and knowing*. Oldenburg: Didaktisches Zentrum.

Hammer, D. H., & Elby, A. (2002). On the form of personal epistemology. In B. K. Hofer & P. R. Pintrich (Eds.), *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 169–190). Mahwah, NJ: Lawrence Erlbaum.

Heslep, R. D. (1997). *Philosophical thinking in educational practice*. Westport, CT: Praeger.

Hiller, G. G. (1976). *Konstructive Didaktik [Constructivist Didaktik.]*. Duesseldorf: Paedagogischer Verlag Schwann.

Hofer, B. K. (2000). Dimensionality and disciplinary differences in personal epistemology. *Contemporary Educational Psychology*, *25*, 378–405.

Hofer, B. K. (2001). Personal epistemology research: Implications for learning and teaching. *Educational Psychology Review*, *13(4),* 353–383.
Hofer, B. K. (2004a). Epistemological understanding as a metacognitive process: Thinking aloud during online searching. *Educational Psychologist*, *39(1)*, 43–55.
Hofer, B. K. (2004b). Exploring the dimensions of personal epistemology in differing classroom contexts: Student interpretations during their first year of college. *Contemporary Educational Psychology*, *29*, 129–163.
Hofer, B. K., & Pintrich, P. R. (1997). The development of epistemological theories: Beliefs about knowledge and knowing and their relation to learning. *Review of Educational Research*, *67*, 88–140.
Hofer, B. K., & Pintrich, P. R. (Eds.) (2002). *Personal epistemology: The psychology of beliefs about knowledge and knowing*. Mahwah, NJ: Lawrence Erlbaum.
Hopmann, S., & Riquarts, K. (1995). Staring a dialogue: Issues in a beginning conversation between Diadaktik and the curriculum traditions. *Journal for Curriculum Studies*, *27(1)*, 3–12.
Jank, W., & Meyer, H. (2002). *Didaktische Modelle [Didaktikal models.]*. Berlin: Corneslon Scriptor.
Jarolimek, J., & Foster, C. D. (1985). *Teaching and learning in the elementary school*. New York: Macmillan.
Jarolimek, J., Foster, C. F., & Kellough, R. (2005). Teaching and learning in the elementary school. Upper Saddle River, NJ: Merill Prentice-Hall.
Johnston, P., Woodside-Jiron, H., & Day, J. (2001). Teaching and learning literate epistemologies. *Journal of Educational Psychology*, *93(1)*, 223–233.
Kane, R., Sandretto, S., & Heath, C. (2002). Telling half the story: A critical review of research on the teaching beliefs and practices of university academics. *Review of Educational Research*, *72(2)*, 177–228.
Kansanen, P. (1995). The Deutsche Didaktik. *Journal for Curriculum Studies*, *27(4)*, 347–352.
Kansanen, P. (2002). Didactics and its relation to educational psychology: Problems in translating a key concept across research communities. *International Review of Education*, *48(6)*, 427–441.
Kansanen, P. (2003). Studying – the realistic bridge between instruction and learning. An attempt to a conceptual whole of the teaching–studying–learning progress. *Educational Studies*, *29(2/3)*, 221–232.
Kardash, C. M., & Howell, K. L., (2000). Effects of epistemological beliefs and topic-specific beliefs on undergraduates cognitive and strategic processing of dual-positional text. *Journal of Educational Psychology*, *92*, 524–535.
Kattmann, U., Duit, R., Gropengießer, H., & Komorek, M. (1996). *Educational reconstruction – bringing together issues of scientific clarification and students' conceptions*. Paper presented at the Annual Meeting of the National Association of Research in Science Teaching (NARST), St. Louis, MO.
Kauchak, D., Eggen, P., & Carter, C. (2002). *Introduction to teaching: Becoming a professional*. Upper Saddle River, NJ: Merill Prentice-Hall.
King, P. M., & Kitchener, K. S. (1994). *Developing reflective judgment*. San Francisco, CA: Jossey-Bass.
Knefelkamp, L. L. (1999). Introduction. In W. G. Perry (Ed.), *Forms of ethical and intellectual development in the college years. A scheme* (pp. xi-xxxvii). San Francisco, CA: Jossey-Bass.
Kuhn, D., & Weinstock, M. (2002). What is epistemological thinking and why does it matter? In B. K. Hofer & P. R. Pintrich (Eds.), *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 121–144). Mahwah, NJ: Lawrence Erlbaum.
Kuhn, D., Cheney, R., & Weinstock, M. (2000). The development of epistemological understanding. *Cognitive Development*, *15*, 309–28.
Lake, K., & Kafka, K. (1996). Reporting methods in grades K-8. In T. Guskey (Ed.), *ASCD 1996 Yearbook: Communicating student learning* (pp. 90–118). Alexandria, VA: Association for Supervision and Curriculum Development.
Lambert, N., & McCombs, B. (Eds.) (1998). *How students learn: Reforming schools through learner-centered education*. Wasington, DC: American Psychological Association.

Lin, C. H. (2001). Epistemological development and academic performance among elementary students. *Journal of National Taichung Teachers College*, *15*, 191–206.

Little, T. S., & Little, L. P. (2001). *Looping: creating elementary school communities*. Bloomington, IN: Phi Delta Kappa International (ERIC Document Reproduction Service No. ED458007).

Louca, L., Elby, A., Hammer, D., & Kagey, T. (2004). Epistemological resources: Applying a new epistemological framework to science instruction. *Educational Psychologist*, *39(1)*, 57–68.

McCaslin, M., & Good, T. (1996). The informal curriculum. In D. Berliner & R. Calfee (Eds.), *Handbook of Educational Psychology* (pp. 622–670). New York: Macmillan.

Meyer, H., & Vogt, D. (1997). *Schulpädagogik, Band I: Die Menschen zuerst [School Pedagogy, Volume I*; *The people first]*. Oldenburg: Zentrum für pädagogische Berufspraxis.

Naegli, P. (2006). United States citizenship. *EdHelper*. Retrieved January 7, 2007, from http://www.edhelper.com.

Noah, H. J. (1985). Comparative education. In T. Husén and T. Neville Postlethwaite (Eds.), *The international encyclopedia of education. Research and studies* (pp. 869–872). New York: Pergamon Press.

Noak, E. G. (1999). *Comparing U.S. and German education: Like apples and sauerkraut. Phi Delta Kappan*, *80(10)*, 773–76.

Ornstein, A. C., & Hunkins, F. P. (2004). *Curriculum: Foundations, principles, and issues*. Boston, MA: Pearson.

Pearl, A., & Pryor, C. R. (2005). *Democratic practices in education. Implications for teacher education*. Lanham, MD: Rowman & Littlefield.

Perry, W. G. Jr. (1970). *Forms of intellectual and ethical development in the college years: A scheme*. New York: Holt, Rinehart & Winston.

Phillips, D. (2001). Reconstructing education in Germany: Some similarities and contrasts in the postwar and post-unification rethinking of educational provision. In L. J. Limage (Ed.), *Democratizing education and educating Democratic citizen. Intenrational and historical perspectives* (pp. 69–83). New York: RoutledgeFalmer.

Pintrich, P. R. (2002). Future challenges and directions for theory and research on personal epistemology. In B. K. Hofer & P. R. Pintrich (Eds.), *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 389–414). Mahwah, NJ: Lawrence Erlbaum.

Purves, A. C. (1988). General education and the search for a common culture. In I. Westbury & A. C. Purves (Eds.), *Cultural literacy and the idea of general education* (pp. 1–8). Chicago, IL: University of Chicago Press.

Qian, G., & Alvermann, D. (2000). The relationship between epistemological beliefs and conceptual change learning. *Reading Writing Quarterly*, *16*, 59–74

Qian, G., & Pan, J. (2002). A comparison of epistemological beliefs and learning from science text between American and Chinese high school students. In B. K. Hofer & P. R. Pintrich (Eds.), *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 389–414). Mahwah, NJ: Lawrence Erlbaum.

Schommer, M. (1990). Effects of beliefs about the nature of knowledge on comprehension. *Journal of Educational Psychology*, *82*, 498–504.

Schommer, M., Crouse, A., & Rhodes, N. (1992). Epistemological beliefs and mathematical text comprehension: Believing it is simple does not make it so. *Journal of Educational Psychology*, *84*, 435–443.

Schommer-Aikins, M. (2004). Explaining the epistemological belief system: Introducing the Embedded Systematic Model and coordinated research approach. *Educational Psychologist*, *39(1)*, 19–29.

Schraw, G. (2001). Current themes and future directions in epistemological research: A commentary. *Educational Psychology Review*, *13(4)*, 451–64.

Schraw, G., & Olafson, L. (2002). Teacher's epistemological worldviews and educational practices. *Issues in Education*, *8(2)*, 99–148.

Shapiro, J., & Kilbey, D. (1990). Closing the gap between theory and practice: Teacher beliefs, instructional decisions and critical thinking. *Reading Horizons*, *31(1)*, 59–73.

Slavin, R., Karweit, N., & Madden, N. (Eds.) (1989). *Effective programs for student at risk*. Needham Heights, MA: Allyn & Bacon.

Smith, C. L., Maclin, D., Houghton, C., & Hennessey, M. G. (2000). Sixth-grade students' epistemologies of science: The impact of school science experiences on epistemological development. *Cognition & Instruction*, *18(3)*, 349–422.

Steinbring, H. (1991). The concept of chance in everyday teaching: Aspects of a social epistemology of mathematical knowledge. *Educational Studies in Mathematics*, *22(6)*, 503–522.

Tsai, C. -C. (2002). Nested epistemologies: Science teachers' beliefs of teaching, learning and science. *International Journal of Science Education*, *24(8)*, 771–783.

Vygotsky, L. S. (1978). *Mind and society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press.

Weinreich, U. (1963). *Language in contact: Findings and problems*. The Hague: Mouton.

Westbury, I. (1998). Didaktik and curriculum studies. In B. B. Gundem & S. Hopmann (Eds.), *Didaktik and/or curriculum: An international dialogue*. New York: Peter Lang.

Westphal, E. (1990). *Unterricht und Leben. Zur Theorie und Praxis lebensproblemzentrierter Unterrichtsgestaltung [Lessons and life. About theory and practice of life-problem-centered lesson planning.]*. Oldenburg: Zentrum für pädagogische Berufspraxis.

Westphal, E. (2002). *Die Rehabilitation des Wissens. Zur Entwicklung einer pädagogischen Tätigkeitsverfassung [The rehabilitation of knowledge. About the development of a pedagogical approach.].* Oldenburg: Zentrum für pädagogische Berufspraxis.

White, B. C. (2000). Pre-service teachers' epistemology viewed through perspectives on problematic classroom situations. *Journal of Education for Teaching*, *26(3)*, 279–306.

Whitebread, D. (2000). Teaching children to think, reason, solve problems and be creative. In D. Whitebread (Ed.), *The psychology of teaching and learning in the primary school* (pp. 140–164). New York: RoutledgeFalmer.

Wilmore, E. L. (2004). Principal induction: A standards-based model for administrator development. Thousand Oaks, CA: Corwin Press.

Windschitl, M., & Andre, T. (1998). Using computer simulations to enhance conceptual change: The roles of constructivist instruction and student epistemological beliefs. *Journal of Research in Science Teaching*, *35(2)*, 145–160.

Wineburg, S. S. (1991). On the reading of historical texts: Notes on the breach between school and academy. *American Educational Research Journal*, *28(3)*, 495–519.

Winsor, D. L. (2006, April). Intra-relatedness of Theory of Mind and Epistemology In Young Children. Paper presented in F. C. Haerle (Chair/Organizer), *Measuring Children's Personal Epistemology and Its Relevance for Education.* Symposium conducted at the American Educational Research Association (AERA) Annual Meeting, San Francisco, USA.

Woolfolk, A. E. (2001). *Educational Psychology*. Boston, MA: Allyn and Bacon.

Chapter 8
A Sociocultural Exploration of Epistemological Beliefs

Iris Tabak and Michael Weinstock

Abstract Recent research points to the centrality of epistemological knowledge in subject-matter learning and reasoning. However, our understanding of factors that might influence epistemological development is still fairly limited. In this chapter, we synthesize results from a series of cross-sectional studies in order to consider sociocultural perspectives of epistemological development, and the role that schooling, community, and culture play in this process. An overall sample of 390 Israeli adolescents completed an epistemological reasoning questionnaire, adapted from Kuhn et al. (2000), which assesses whether respondents hold absolutist, multiplist, or evaluativist positions concerning the truth-value of knowledge claims in values, social, and physical domains. Participants included secular Jewish 7th, 9th, and 11th graders, religious Jewish 7th graders, and Bedouin 7th and 9th graders. Thus, we were able to compare differences in epistemological positions across grade-level and cultural background. There were similar grade-level differences in both groups, but the Bedouins had higher percentages of absolutists than the Jews in all domains, particularly in values. Grade-level changes across cultural groups suggest that schooling is a factor in changes in epistemological understanding. However, cultural differences suggest that cultural values and out-of-school interactions might also be a factor in epistemological understanding. Sociocultural theory provides a framework that can explain patterns that diverge from typical developmental models, and existing literature on the epistemological beliefs of particular cultural groups. The results might help explain why it has been difficult to find consistent age-related epistemological development.

8.1 Introduction

Increasingly, educators recognize that learning is contingent not only on the particular ways in which subject-matter content and skills are presented and experienced, but also on the structure and culture of the learning environment (Bransford et al., 2000), its congruence with students' cultural capital (e.g., Lee,

---

Ben-Gurion University of the Negev, Israel

M. S. Khine (ed.), *Knowing, Knowledge and Beliefs: Epistemological Studies across Diverse Cultures.*

2003), as well as a myriad of learner characteristics. These include learners' attitudes toward school and learning (Wigfield et al., 1998), future orientations (Nurmi, 1991), and conceptual ecologies (Strike & Posner, 1992). In particular, students' epistemological perspectives, their views of the source of knowledge, its certainty, simplicity, and the justifications for knowing, have been found to affect the ways in which students attend to and integrate new knowledge and skills (Hofer, 2001; Hofer & Pintrich, 1997; Hogan, 1999; King & Kitchener, 1994; Schommer, 1990; Songer & Linn, 1991). Understanding how these perspectives about knowledge emerge and what influences the course of their development can expand our understanding of human cognition, as well as suggest ways in which we can enhance subject-matter learning, and improve educational experiences.

Developmental psychologists have studied epistemological knowledge for nearly four decades. This line of research originates with Perry (1970) who set out to describe the intellectual and ethical development of college undergraduates, and articulated nine epistemological positions which he identified in longitudinal studies of these students. These positions reflect movement from a view of knowledge as certain, to a view of knowledge as radically relative to a qualified relativity perspective. Subsequent research studied particular types of epistemological beliefs[1] and their developmental course (e.g., Belenky et al., 1986; Kuhn et al., 2000; Magolda, 1992; Schommer, 1990), as well as the relationship between epistemological positions and decision-making, problem solving and other factors (King & Kitchener, 1994; Weinstock & Cronin, 2003). The types and number of epistemological beliefs that have been identified to date (King & Kitchener, 1994; Kuhn et al., 2000; Leadbeater & Kuhn, 1989; Perry, 1970; Weinstock & Cronin, 2003) have been distilled by some to three general positions (Hofer & Pintrich, 1997; Kuhn et al., 2000; Martin et al., 1994). This distilled framework is the framework that we adopt in this chapter.

There is a general consensus that the developmental course progresses through the three positions of this distilled framework (Hofer & Pintrich, 1997; Kuhn et al., 2000; Martin et al., 1994). Development proceeds from (1) "absolutist" – the conception of knowledge and knowing as objective and absolute; to (2) "multiplist" – regarding all knowledge as subjective and relative and, therefore, indeterminate because of multiple points of view; to (3) "evaluativist" – the acceptance and integration of subjective and objective aspects of knowledge that would permit a degree of evaluation and judgment of knowledge claims. Although this model is often presented as levels of epistemological development, it does not connote a strict stage model.

---

[1] The term "beliefs" is used in this chapter because of its clarity in common language. There is considerable debate in the field about what term should follow "epistemological" and about the epistemological dimensions, methods, development, and the role of context that have become associated with the different terms. In fact, the construct described in this chapter commonly uses epistemological understanding or thinking, but has been less concerned with staking out a claim based on a particular term. This terminology has been associated with the most general developmental model (Kuhn & Weinstock, 2002) that is the focus of this chapter.

Unlike a more typical conception of development as age-related change, educational level and experience have appeared as a key factor in epistemological change in both longitudinal and cross-sectional studies (King et al., 1983; Kuhn et al., 2000; Perry, 1970; Schommer et al., 1997), to a greater degree than age (Hofer & Pintrich, 1997; Kuhn, 1991). This raises the question of whether epistemological development is a natural, universal development, or if it is influenced by engagement in particular goal-directed cultural activities, such as schooling.

Some recent work has challenged earlier developmental assumptions as well as the ways in which epistemological beliefs have been conceptualized. For instance, the assumption that epistemological positions are hierarchical and pose a progression in sophistication or adequacy has been challenged (Gottlieb, 2007). Similarly, while epistemological beliefs are often viewed as coherent and ubiquitous "theories of knowledge," Hammer and Elby (2002) as well as others (e.g., Hogan, 2000) propose an alternative, situated or "knowledge in pieces" conceptualization of epistemological beliefs that is culturally sensitive (Gottlieb, 2007).

As the chapters in this volume suggest, the nature of epistemological positions, their origin and development are complex, varied, and multidimensional. In this chapter, we synthesize a series of cross-sectional studies. The studies examined epistemological positions in unique contexts, such as a science-immersion school and a Bedouin school. These studies revealed epistemological patterns that depart from the patterns typically found in earlier studies. We use these results to explore a sociocultural approach to epistemological development. We consider how a sociocultural perspective can help us understand how differing contexts and different types of interaction might foster particular epistemological perspectives.

8.2 A Synthesis of Cross-sectional Studies

We present three studies that diverge somewhat from the course of development commonly described in the literature. In general, the trend of development, in our data, is from an absolutist perspective toward a more relativist perspective, with the majority of adolescents maintaining multiplist beliefs, as would be expected. But when comparing groups, the courses of development show clear inconsistencies with one another both in terms of timing and between domains. One of the studies reviewed focuses on cultural differences, comparing the epistemological levels of Bedouin and Jewish Israeli adolescents across three grades (Weinstock, 2007, March). A second study focuses on differences in engagement in domain activities, comparing the epistemological levels of Israeli adolescents studying in a regular versus a science-oriented or science-immersion school (Tabak & Weinstock, 2005). The third compares the epistemological levels of Israeli adolescents studying in a regular (Jewish secular) versus a Jewish religious (but public) school.

8.2.1 Study Instrument

Each of the studies employed the Epistemological Thinking Assessment (ETA) (Kuhn et al., 2000) to capture cross-domain epistemological positions. We use the term cross-domain to refer to assessments that pose the same or similar questions but in reference to different domains, typically by inserting the name of the discipline (Buehl et al., 2002; Hofer, 2000), or the tasks (Kuhn et al., 2000) into the different questions. The conceptual basis (Perry, 1970; King & Kitchener, 1994; Kuhn, 1991; Kuhn & Weinstock, 2002) of the ETA is that people's epistemological beliefs come into play when they are confronted with uncertain, discrepant knowledge claims. The ETA asks whether it is possible to judge whether one account is more correct than the other when presented with competing accounts in five broad domains: taste, ethical, aesthetic, social and physical. For example, within the physical domains students are presented with the following scenario: "Robin believes one book's explanation of what atoms are made up of. Chris believes another book's explanation of what atoms are made up of." Students are then asked whether only one of them can be correct; whether they can both be somewhat correct, but one of them more correct than the other; or if they can both be somewhat correct but neither can be more correct than the other. This instrument has enabled even younger students to demonstrate fairly sophisticated perspectives, and was useful in identifying variations in developmental patterns across domains.

8.2.2 Study Contexts and Overview of Main Results

The school system in Israel is a centralized system with a standard curriculum. Grades K-12 are included in an obligatory free public education system. The school system includes major institutional divisions. It consists of two major divisions: Jewish and Arab. The Jewish section is further divided into secular and religious schools. In some regions, religious boys and girls study separately, but even if boys and girls attend the same school, they are often taught in separate classrooms especially in the older grades. Pupils in the Jewish schools learn in Hebrew, and pupils in the Arab schools learn in Arabic. The pupils in the Arab schools also learn Hebrew as a second language, whereas Arabic is not required in the Jewish schools. Although there are a few instances of Arabs studying in Jewish schools, and a small number of integrated programs, for the most part the system is segregated in that it separates between Jewish and non-Jewish students. Although there is a standard curriculum there is some flexibility that enables different divisions, such as religious or Arab to tailor the curriculum to the local community needs. Of an individual school's curriculum 75% needs to adhere to the standard core curriculum and 25% can consist of localized curricula, since 2000 there is a general trend toward increasing school curricular autonomy (Sprinzak et al., 2004).

School attendance is by residential districts ("the neighborhood school"). For the most part, Jews and Arabs live in separate cities and towns or, in the few cities with a mixed population, in different residential neighborhoods. Distinct Jewish and Arab schools are maintained even in those cities with a mixed population. There are also public magnet schools that focus on a particular aspect such as art, science, secular-religious or Arab-Jewish coexistence. Registration for these schools is not limited to a particular residential area, but often includes entrance exams and/or a maximal registration quota.

A school day typically consists of four–five 45 min class sessions at the younger grades and five–six 45 min class sessions at the older grades. Most instruction is traditional textbook-based recitation style, with additional group-work and inquiry projects in different topics. Class size is generally 25–40 students per class.

The regular school – The global adolescent: "everyone has a right to his or her opinion." The school we refer to as "the regular school" in this synthesis is a rural regional Jewish school with students from a number of small urban and agricultural communities in the area (mostly moderate to high SES). The school is a combination boarding and day school. It is a "regular" school in that it is a public school with no admissions requirements, and is composed of a heterogeneous student body both in terms of socioeconomic status and academic abilities.

The distribution of the students in this school resembled that of the American samples used in the initial study using the ETA (Kuhn et al., 2000). At least half of these adolescents were multiplists in each of the domains with an increase in the number of evaluativists in the social and physical domains in the 11th grade. Of the total sample, over 90% were multiplist in the domains of taste and aesthetics, whereas 57% were multiplist in the values domain and 50% were multiplist in each of the social and physical domains. Moreover, like in almost all studies of personal epistemology using this and a good variety of other instruments, there were no differences by gender. These results, in the regular school sample, are in line with what would have been predicted by the findings in Kuhn et al. (2000), and are consistent with the general trend of epistemological development described in other studies (e.g., Leadbeater & Kuhn, 1989; King & Kitchener, 1994). They will serve as the main point of comparison with the distributions found in the other populations.

The science school – qualifying the social but conserving the science. The science school is a public magnet school (grades 1 through 9) in a central city in Israel focusing on science. Students must pass entry examinations in order to be admitted to the school, and must pay some fees to attend the school. Admission tests include psychometric assessments of general intellectual ability, quantitative ability, and social competence (e.g., how well children are able to work with others). The school is obligated to admit 35% of its students from typically underrepresented neighborhoods, and it provides financial assistance to students with economic difficulties. The curriculum conforms to the programs outlined by the Ministry of Education, but includes an extended science curriculum. There are more hours devoted to science than in other schools, and science instruction takes place in groups about half the size of typical Israeli classrooms.

The notable difference between the science and regular students is that more science students were absolutist in the physical domain. In the ninth grade just slightly more than a third were multiplists in this domain compared with over 60% of the regular students. The science students were also more evaluativist in the social domain. In sum, the science students were less multiplist than the regular students in the physical and social domains, but did not show differences in the other domains.

The Bedouin school – radical relativism rejected: an absolute counter to majority. The Bedouin school is in a town in the south of Israel where the Arab population is almost entirely Bedouin. Bedouins are traditionally rural, living in small (often nomadic) villages. Beginning in the late 1960s there has been a government policy to encourage their settlement in several specifically Bedouin towns (Abu-Rabia-Queder, 2005). Despite these efforts there are still a good number of Bedouins who live in what are considered by the government to be "unrecognized villages." Because they are unrecognized, these villages may not have elementary schools and do not have middle or high schools. At whatever level schools are lacking, pupils from the unrecognized villages go to school in the towns. There is a high dropout rate among all Bedouins (65% of southern Bedouins compared with 10% of Jews), and this figure is even higher in the unrecognized villages (Abu-Saad, 2004). Girls drop out at a higher rate than boys, particularly in the unrecognized villages (Abu-Rabia-Queder, 2005). (It should be noted, however, that in the sample in the current study, there was no significant decrease in the numbers of pupils between the grades, and no differences between the Bedouins and the Jews.) In general, in Israeli society the Bedouins have a low socioeconomic status.

There were very clear differences between the Bedouin students and both the Jewish groups at the regular and science schools. The Bedouins not only were markedly less multiplist than the regular Jewish students in each of the domains, but also they tended not to be multiplist at all. Although in every study using the ETA, the far majority, even at the fifth grade (Kuhn et al., 2000) are multiplist in the taste and aesthetic domains, only 15% and 24% of the Bedouins were multiplist in each of those domains respectively, compared with the 90% of the Jewish students who were multiplist. While notably more absolutist in the values domain, with more than half being so, in the physical and social domains there tended to be more absolutists and evaluativists than among the regular Jewish students.

Another striking difference is that, unlike in most studies and unlike the Jewish students, there were gender differences among the Bedouin students. In each of the domains except for values, the Bedouin girls were significantly more likely to be evaluativist and significantly less likely to be absolutist than the Bedouin boys. One third of the Bedouin boys were absolutist in the physical and social domains compared with 10% and 20% of the Bedouin girls and 14% and 3% of the regular Jewish students respectively.

The religious school – just like other teens, except in values. The religious school is in a city in the south of Israel with a population of mostly moderate to low SES, and many immigrants from the former Soviet Union and Ethiopia. The school is a public religious school. At the seventh-grade level (from which our sample is taken) girls and boys study the same curriculum but in separate classrooms. The ETA was administered in this school as part of another study and therefore only the girls were sampled. In its charter the school emphasizes the dual goals of cultivating graduates who live their lives according to the values of the Jewish religion, but who are also well integrated in Israeli society at large. They specifically note completing matriculation exams as a school goal. As is customary in most Jewish religious schools in Israel, the curriculum includes extensive religious studies, and school life is somewhat different from secular schools in that the school day includes prayer, and there is an emphasis on promoting particular day-to-day values both within and outside of school. For example, out-of-school behaviors might be addressed in school as a school-relevant disciplinary issue, for instance, if a student is seen engaging in immodest behavior outside of school (e.g., if she is seen going to a dance club scantily dressed).

The religious school students had patterns mostly similar with the seventh-grade girls in the Jewish regular group. They differed from the secular Jewish group only in the domain of values with less than half being multiplist compared with over two thirds of the secular group. They also tended to be more absolutist with a third being so compared with 7% of the secular seventh-grade girls. But in all domains, including values, the religious Jewish girls differed from the Bedouin girls, who, it should be noted, would also be considered to be religious. Like with the secular Jews, the religious Jews were more likely to be multiplist than the Bedouins even though, except with values as noted above, the percentages of multiplists were generally lower than with the secular Jewish girls.

8.3 Contrasts, Enigmas, and Reflections

Although there are no clear patterns of epistemological development by age (Chandler, 2002), it is reasonable to assume that adolescents in standard, Western educational contexts would tend to be multiplists at least until the final years in high school when a majority may become evaluativist (Chandler et al., 1990; Kuhn et al., 2000; Weinstock et al., 2006). The trend from childhood through adolescence is proposed to be, and for the most part found, away from absolutist thinking and toward the more relativist thinking of the multiplist and then evaluativist levels.[2] Moreover, in the domains as assessed by the ETA (Kuhn et al., 2000), it is assumed that people will make the transition from absolutist to multiplist first in the taste and

[2] Results from the ETA have yielded different patterns than some interview-based studies. The ETA (Kuhn et al., 2000) shows a general progression from absolutist thinking toward multiplism and evaluativism, however, some interview-based studies suggest that most people maintain multiplist positions and that evaluativist positions are found only rarely and then mostly among those with advanced academic training (King & Kitchener, 1994; Weinstock & Cronin, 2003).

aesthetic domains, then in the values domains, and finally in the physical and social domains. They will then make the transition from multiplist to evaluativist in the reverse order, so that they will become evaluativist first in the physical and social domains. Following this, they may or may not become evaluativist in the other domains, as especially the taste and aesthetics domains might appear to be beyond adjudication (Nicholls & Thorkildsen, 1988). Empirically, this has appeared to be the case (Kuhn et al., 2000; Weinstock et al., 2006) with the exception that more people appear to remain absolutist in the values domain than expected, although a clear majority at most ages are multiplist. In the taste and aesthetic domains, people of all ages, including children in the third grade who have been given the assessment, have been found to be overwhelmingly multiplist.

However, as summarized above, in administering the ETA to samples that differ in a number of ways from the North American schoolchildren or adolescents in standard schools, we have found that these patterns do not hold up. The findings from these samples – drawn from a science-oriented middle school, a Bedouin Arab combined middle and high school, and a Jewish religious girls' middle school – showed patterns of epistemological positions that diverged across grade and domain from the findings with a sample drawn from a regular Jewish combined middle and high school. As expected, the regular school had patterns of epistemological positions similar to those found in an American sample (Tabak & Weinstock, 2005; Weinstock et al., 2006).

With the exception of a general trend away from absolutism toward relativism in adolescents, the samples displayed unique patterns of epistemological positions across grades, gender, and domains. The divergence from the typical findings has prompted us to consider what gives rise to the epistemological positions. Rather than simple natural age-related or general school-related development, we suspect that sociocultural factors come to play in what appears to be epistemic socialization. That is, school and community values and practices would seem to influence what positions toward knowledge are desirable or acceptable. Moreover, in some instances the values and practices of school and community might diverge, thus producing patterns of epistemological development that would not be predicted by the typical model.

In this section, we first consider epistemological development from a sociocultural perspective. We ground this discussion in the context of schooling, because education has been found to play a key factor in epistemological development (Hofer & Pintrich, 1997; King et al., 1983; Schommer et al., 1997). In fact, evaluativist positions are mainly found among those with advanced college degrees (King & Kitchener, 1994; Kuhn et al., 2000; Weinstock & Cronin, 2003). Following our discussion of the epistemological socialization of schooling, we describe how some of our findings run counter to what might be predicted based on extant literature and typical developmental models. We proffer some possible accounts of how these groups' sociocultural circumstances might influence epistemological beliefs and the patterns of their development. The characteristics we focus on as possible influences include immersion-in or privileging of a domain, cultural background and social (minority/majority) status.

8.3.1 A Sociocultural Perspective on Schooling and Epistemological Development

That day-to-day human activity shapes our worldviews and our notions of self, of self in relation to others, and of knowledge is central to sociocultural theory (Cole, 1996; Duranti, 1997; Rogoff, 1993; Wells, 1999). In particular, in the realm of schooling, different forms of classroom interaction can foster different conceptions of learning, authority, and identity (e.g., Cazden & Beck, 2003). We believe that much of what has been said about the way classroom interaction shapes conceptions of learning can inform our understanding of how classroom interaction can shape conceptions of the nature of knowledge. Moreover, the nature of knowledge is seldom an explicit part of the curriculum (with limited recent exceptions in research in science teaching and other disciplines). In the absence of explicit instruction, the cultural messages communicated through interaction patterns are even more critical, and are often said to carry more weight than formal and overt instruction (Giroux, 2001; Jackson, 1968; LeCompte, 1978).

Consider a ubiquitous pattern found in many classrooms consisting of teacher–student–teacher turns (Cazden, 2001; Cazden & Beck, 2003), most commonly referred to as *Initiation-Response-Evaluation* sequences (IRE) (Mehan, 1979). In these exchanges, a teacher asks students a "test question" (Nystrand, 1997), where the speaker knows the answer but asks the question in order to assess the audience's knowledge; students are then expected to answer this question; and the teacher follows with an evaluation of the students' response. This structure is said to foster a view of learning as the acquisition of an authoritative canon (Lemke, 1990; Nystrand, 1997; Wertsch, 1998). This in turn can cultivate a view of knowledge as objective, uncontested, immutable, qualities that are consonant with absolutist beliefs.

However, extant classroom interaction, and progressively more so, is not limited to this strict and limited form of interaction. Lemke (1990), for example, refers to teacher–student–teacher exchanges as *triadic dialogue* to signify that the dialogue is structured around a sequence of three turns but that the form and content of the turns might be different than initiation, response and evaluation. When the third turn takes the form of feedback (IRF) rather than evaluation (Wells, 1993), new opportunities open for making the triadic dialogue a setting for knowledge refinement. This suggests to students that there is more to learning than rote memorization, such as analysis, debate and extension of ideas. Such activities invite more relativist positions toward knowledge, because it makes sense to consider alternatives only if the alternatives are likely to have some truth value.[3] In this way, the process of considering and analyzing alternatives can engender

[3] Arguably, it is also possible that considering alternatives is aligned with absolutist conceptions as well, in which case alternatives are explored in order to arrive at the "real" or "ultimate truth." However, within the culture of schooling, which generally values efficiency (Doyle, 1983), we believe the multiplist interpretation is more plausible.

beliefs that different alternatives exist and that they each have value, which is consistent with relativist, or multiplist positions.

Opening triadic dialogue to considering alternatives admits multiplist epistemology, but we contend that other widespread classroom practices inhibit evaluativist epistemology. Currently, teachers are pushed to adopt constructivist pedagogy, and to engage in student-centered pedagogy. While we support these initiatives, we believe that these educational approaches can be narrowly conceived, or even misconceived (Brown, 1992), resulting in practices that inhibit evaluativist epistemology. Perhaps as a backlash to critiques of authoritarian transmission models, teachers now tend to emphasize giving students opportunities for self-expression and to communicating the validity of multiple solutions and perspectives. These are laudable goals. However, recognizing that often there is "no one right answer" does not necessarily imply that one answer cannot be better than the other, and learning the criteria within each domain for evaluating competing claims is an important part of subject-matter learning, and of epistemological development. It is not clear that this idea is communicated well along with ideas of progressive pedagogy and reform. In addition, teachers operate under severe time constraints (for example, due to classroom management issues, or overly ambitious content goals), so that even if teachers are aware of its significance attention to issues of critique, evaluation and adjudication is often absent. As a result, the view of knowledge that students are exposed to through day-to-day classroom interaction is one in which multiple opinions are raised, but the dialogue goes no further than raising diverse opinions. Consequentially, the underlying message is that these opinions are deemed equally valid, and that there is no motivation for trying to judge or choose among them, thus sustaining multiplist positions.[4]

These messages are further reflected in broader societal narratives of the postmodern era, which evoke a sense of uncertainty and pluralism (Gergen, 1991; Lyotard, 1984; Rorty, 1979). This might explain the prevalence of multiplist views that have been identified in many studies to date (Hofer & Pintrich, 1997; King & Kitchener, 1994; Weinstock & Cronin, 2003), and that are reflected in our findings from the regular school.

Evaluativist positions are rare, and seem to be found mainly in conjunction with higher education and advanced degrees (King & Kitchener, 1994; Kuhn et al., 2000; Weinstock & Cronin, 2003). Graduate education seems to be successful in fostering evaluativist positions, because it mostly follows an apprenticeship model and learners engage in the process of raising conjectures, analyzing data, and constructing arguments. The process of argumentation is central in academia, and confronting critique and debate may focus learners on the ways in which valued and credible alternatives can be evaluated and adjudicated. This poses a critical distinguishing feature between multiplist and evaluativist epistemologies.

---

[4] This may be an oversimplification of knowledge claims in the classroom, as much research points to the inequitable valuing and devaluing of different student perspectives based on factors such as gender and race (e.g., Darder et al., 2003). Nonetheless, these interactions may play a more significant role in promulgating social categories and hierarchies than in cultivating qualified relativist epistemologies.

Some advocate incorporating similar experiences (i.e., inquiry learning) in primary and secondary education in order to (among other goals) cultivate more evaluativist epistemologies (e.g., Bransford et al., 2000). There is some debate in the literature over whether engagement in firsthand investigations can advance a movement away from absolutism and toward evaluativism (Bell & Linn, 2002; NRC, 2000) or whether explicit instruction on the nature of knowledge is required (Khishfe & Abd-El-Khalick, 2002). If IRE and IRF classroom discourse sequences can foster absolutist and multiplist positions in the absence of overt instruction then it may be equally plausible to expect inquiry learning to cultivate evaluativist positions. However, in the case of evaluativism and inquiry learning it may be that the discord between curricular messages and societal messages may demand explicit instruction in order to sway the tone toward the curricular and evaluativist messages.

Our data reveals mixed results that suggest a number of nuances surrounding these issues of tacit epistemological learning through interaction, and of accord and discord between classroom and community culture. In the next two sections we describe two surprising patterns in our results. We present a possible sociocultural explanation for these patterns, which at this point, in the absence of ethnographic data and analysis of classroom interactions in the sampled classrooms, is conjecture.

8.3.2 Immersion in and Privileging of a Domain

In the science school we studied, the curriculum includes a considerable amount of inquiry-oriented and project-based activities. In science especially, students have the opportunity to raise questions and engage in the process of knowledge generation, which inevitably would include exposure to multiple hypotheses and warrants. This, in turn, should help promote a movement away from absolutist and toward evaluativist positions, provided enough attention is geared toward critique and evaluation. Overall, the findings from the science school are consistent with this expectation. The science group was much less multiplist than the regular group in both the social and physical domains. No more than 50% were multiplist in either domain at either grade level, with more becoming evaluativist in the ninth grade, whereas 60% or more of the regular school pupils were multiplist in both domains and all grade levels.

However, what was surprising was that the science students were also notably more absolutist in the physical domain. That is, in the physical domain, they were mainly divided between evaluativist and absolutist positions. In one respect this supports the idea that educational experiences that require students to argue from evidence, and defend their positions in the face of alternatives can foster evaluativist perspectives (e.g., Bell & Linn, 2002; Tabak & Weinstock, 2005). Yet, what seems puzzling still is that within the physical domain the students in the science-centered school appeared to be more absolutist than the students in the regular school. If lack of attention to adjudication in the inquiry learning was the case, then we would expect multiplist positions to prevail within and across domains, however, we do see evaluativist positions, and at the very least we should not see more absolutist positions than in the regular school.

This puzzling result is better explained when considered in conjunction with the findings from the religious girls' data. As we described above, the curriculum and school environment of religious schools is quite different from secular schools, and reflects the practices of the religious communities within which they are embedded. Thus, we expected religious school students to display different epistemological positions and developmental patterns than those found in secular schools in Israel and in North America. In particular, we expected religious students to tend toward absolutist positions (Desimpelaere et al., 1999), because in this cultural setting the resolution of dilemmas across religious, academic and day-to-day domains are governed by religious doctrines under the authority of religious leaders. For example, in religious schools, introducing a new type of activity may require both the principal's and the school Rabbi's approval. Yet, despite this milieu, the religious girls were absolutist only in the values domain and held multiplist positions in all other domains, displaying patterns similar to those found among the girls in the regular (secular) school.

Piagetian-influenced developmental approaches to the study of epistemological beliefs have tended to view absolutist perspectives as less sophisticated and intellectually inadequate. Moreover, those considering religious thinking specifically have argued that religious thinking inhibits individuals from adopting more sophisticated epistemologies (as reviewed in Gottlieb, 2006, 2007). If this is the case, why do the science students also maintain absolutist positions in a domain in which they excel and which is taught in "evaluativist-conducive" ways?

Ironically, though scientific thinking and religious thinking may be considered diametrically opposed, we believe that these two groups of students, those studying in a science-immersion program and those studying in a religion-immersion program convey a similar characteristic of epistemological socialization. Taken together, the two data sets enable us to view the religious school results in a different light that does not attribute absolutist positions to intellectual naivete or to reasoning constrained by indoctrination. Rather, we suggest that in both cases what we are seeing is that immersion-in and privileging (Wertsch, 1998) of a domain can cultivate absolutist positions.

Our argument hinges on two aspects of the data. First, in both groups, in addition to absolutist positions, students also maintained multiplist or evaluativist positions, which show that these students have the capacity to espouse what are considered more sophisticated epistemological positions. Second, and more importantly, in both cases, absolutist positions converged on a culturally significant domain (science for the science-immersion students, and values for the religion-immersion students).

In cases where a particular domain is highly valued and emphasized in the curriculum there are any number of overt and material means that reflect its privileged status, among others, it receives more instructional hours, success in this domain is valued over success in other domains, greater attention is paid to the extent and types of instructional resources used. In addition, there are more nuanced ways in which this domain is marked in day-to-day interaction and activity. These practices can include a more serious or focused tone taken on when this topic is addressed, or discursive patterns that are different from those employed in other domains, such as more direct speech or less hedging ("it seems" or "some sources state that"). Such social, material, and linguistic devices mark the domain as distinct and highly valued.

The question is why might privileging and marking the domain lead to absolutist beliefs? In interpersonal interactions when faced with particular social, material and linguistic devices people draw on their cultural models for interpretation and meaning making (Gee, 1996), such as associating particular speech patterns with masculinity or femininity (Duranti, 1997). This process is not reductive or deterministic. In any given situation a number of cultural models are available as candidates for interpretation and people use a variety of contextual cues, as well as personal histories, to "choose" among them. We suggest that in addition to the cultural models we referred to earlier, those that reflect the postmodern era and that we argued promote multiplist positions, and include ideas such as plurality and the blurring and questioning of boundaries, other cultural models reflecting more traditional Western values are also available. Specifically, models that associate value with things that are limited or singular rather than plural, that are constant rather than transient[5].

In our studies, science and religion were distinct from other domains and also held in deference, thus inviting students to construct interpretations that are different from those made in other domains, and in particular to draw on cultural models associated with deference. This generally led students to "choose" the traditional, singular model rather than the pluralistic model when considering these privileged domains. It is through the association with this model that the domain that is privileged is associated with a conception of knowledge as objective and immutable as reflected in an absolutist epistemology. Of course, additional cultural models might be implicated in these interpretations. In the case of science, these include the image of science in popular culture as a unified institution ("the scientific method") and as a powerful source of objective truths about the world (Aikenhead, 1989; Brandes, 1996; Koballa, 1995). In the case of religion these include the explicit curriculum that states that while other values might exist, the only acceptable values for these students to adopt are those promulgated through the religious doctrines.

8.3.3 Authority and Power Structures

The process of selecting among available cultural models may also explain the patterns we found among the students in the Bedouin school, as well as the differences we found between the Bedouin and "regular" Jewish students. We expected the results from the Bedouin school to be similar to the Jewish-religious school

[5] That such meta-narratives associating singularity and constancy with value exist in Western culture can be gleaned in part from critiques of these traditions (e.g., Derrida, 1978; Irigaray, 1985). Consider also central Western institutions such as monotheism.

(Bedouin communities tend to be observant Muslims) and to be primarily absolutist as suggested by the literature on religious beliefs (Desimpelaere et al., 1999) and on hierarchical collectivist societies' approach to authority (Schwartz, 1999; Wainryb, 1995). Similar to the Jewish-religious girls that we studied, the Bedouin students tended to maintain absolutist positions in the values domain. Unlike our initial expectations, these students did not necessarily tend toward absolutism in all domains rather, compared to the regular Jewish school, they tended to be both more absolutist and more evaluativist. Mainly, they tended not to be multiplists.

We consider this tendency away from multiplism to be the key finding among the Bedouin students. Our proposed sociocultural explanatory framework states that epistemological positions are adopted in part through a process of drawing on particular cultural models in order to interpret day-to-day interactions. These interpretations suggest particular notions concerning the source, truth-value, and justification of knowledge. Within this framework, it appears that what characterizes the Bedouin students' interpretations is a rejection of the cultural model associated with the majority or culture of power.

The Bedouin students have a number of cultural models available to draw from in interpreting day-to-day schooling interactions. One model, is the pluralist model associated with postmodern life available to all adolescents across our different studies. The other, is the model associated with traditional Bedouin culture, which is characterized by hierarchically oriented collectivist norms (Schwartz, 1999; Wainryb, 1995).[6] Such a culture would tend to prescribe social roles that have more or less epistemic authority, which is in line with absolutist epistemologies that maintain that knowledge comes from authoritative objective external sources (Weinstock, 2005, August). There appears to be at least one additional model consistent with evaluativist positions, but at this point we do not know what this model might be or what cultural sources it might draw on. This is a question that merits further investigation.

These two models, the "postmodern" and the Bedouin, would seem to be the most salient to the Bedouin students in our study. Consequently, one could expect these students to draw on either of these two models. However, despite its salience, the postmodern model is significantly not selected. If students were decidedly absolutists we could say that the Bedouin community is insular and that the Bedouin students draw mainly on their specific cultural capital. That they are not strictly absolutist, but are decidedly not multiplists raises the possibility that rather than salience or insularity, what is at play is a rejection of majority models. That is, it suggests that one of the "contextual cues" that individuals use in the "selection" of cultural models in the process of interpretation and epistemological socialization are issues of political power and majority or minority status.

Another interesting finding among the Bedouin students was that there were gender differences in epistemological patterns. This is in contrast to our regular

[6] We make these assertions cautiously, recognizing that there are practices and linguistic devices that characterize cultural groups, while also being wary of assuming essentialist approaches to cultural groups (Gutierrez & Rogoff, 2003).

Jewish school and to most North American samples that have been studied, which did not find significant gender differences.[7] The Bedouin girls were significantly more likely to be evaluativist and significantly less likely to be absolutist than the Bedouin boys.

We believe that this result also suggests that issues of power and social positioning play a role in the selection of the cultural models used to interpret interactions and shape epistemological beliefs. Although all cultural groups in this study prescribe social roles and hierarchical relations to some extent, the Bedouin community is typically strongly patriarchal. For example, Bedouin males often have more access to education than Bedouin Females (Abu-Saad, 1997). Individuals may recognize the cultural structures and norms within which they live and orchestrate their lives within these bounds, while at the same time resist them (e.g., Holland, 1998, p. 120). Within such a constellation, people may tend to "choose" (of course we are not suggesting a cool, conscious process of deliberation) to interpret interactions using the cultural models that are more emancipatory and empowering to them. Authority-oriented cultural models carry with them implications of more constrained roles for women making them less appealing to many Bedouin girls. At the same time, these girls are Bedouin and must also navigate their lives within the confines of a national minority, which may explain why the Bedouin girls, like the Bedouin boys and the Bedouin sample overall veer away from the postmodern, or majority cultural model. Thus, the Bedouin girls appear less absolutist and more evaluativist.

8.4 Conclusion: Beyond "Cold" Epistemology

The findings and analyses that we present converge with recent arguments (e.g., Gottlieb, 2007; Hammer & Elby, 2002) and with the other chapters in this book in calling for a more complex view of epistemological beliefs and epistemological development. It calls for a view that recognizes the multifaceted and dynamic nature of epistemological beliefs. In particular, we suggest that epistemological beliefs be considered from a sociocultural perspective. This means that day-to-day interactions and cultural models play central roles in the formation of epistemological beliefs and in the ways in which they are employed. What follows from this approach, and from our discussion, is that the formation of epistemological beliefs is not only situated and culturally sensitive but that it has to do with how people define themselves and position themselves in relation to others and knowledge/power structures in their communities.

[7] Kuhn and others (Kuhn, 1991; Kuhn et al., 2000; Kuhn et al., 1994; Leadbeater & Kuhn, 1989) have found no differences by gender. King and Kitchener (1994) found that men in half their studies had higher epistemological levels, but noted that the men also had overall higher educational attainment.

One implication, which also resonates with current critiques, is the need to reexamine the hierarchical approach typically taken with respect to epistemological positions and development. This will involve more than just replacing a hierarchical approach with an approach that considers epistemological differences in qualitative ways, because there may be contexts in which one epistemological position is more productive than another. For example, within Western academic domains evaluativist positions have been associated with stronger performance (Hogan, 1999; Smith et al., 2000; Songer & Linn, 1991).

What is most needed at this point is a better understanding of how epistemological beliefs are shaped and constructed through day-to-day interactions. We plan to follow these cross-sectional studies with ethnographic studies that aim to articulate process models of epistemological reasoning and development in situ. We hope that these endeavors will contribute to a better understanding of the nuanced ways in which culture, cognition, and social structures construct epistemologies.

References

Abu-Rabia-Queder, S. (2005). Models of activism: Bedouin women's struggle for inclusion in Israel. *Critical half*, 3(2), 14–18.

Abu-Saad, I. (1997). The education of Israel's Negev Bedouin: Background and prospects. *Israel Studies*, 2(2), 21–39.

Abu-Saad, I. (2004). Separate and unequal: The role of the state educational system in maintaining the subordination of Israel's Palestinian Arab citizens. Social Identities, 10(1), 101–127.

Aikenhead, G. (1989). Scientific literacy and the twenty-first century. In C. K. Leong & B. S. Randhawa (Eds.), *Understanding literacy and cognition: Theory, research and application* (Vol. vii, pp. 245–254). New York: Plenum Press.

Belenky, M. F., Clinchy, B. M., Goldbert, N. R., & Tarule, J. M. (1986). *Women's ways of knowing: The development of self, voice and mind*. New York: Basic Books.

Bell, P., & Linn, M. C. (2002). Beliefs about science: How does science instruction contribute? In B. K. Hofer & P. R. Pintrich (Eds.), *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 321–346). Mahwah, NJ: Lawrence Erlbaum.

Brandes, A. A. (1996). Elementary school children's images of science. In Y. Kafai & M. Resnick (Eds.), *Constructionism in practice: Designing, thinking, and learning in a digital world* (pp. 37–69). Mahwah, NJ: Lawrence Erlbaum.

Bransford, J., Brown, A., & Cocking, R. R. (Eds.) (2000). *How people learn: Brain, mind, experience and schools*. Washington, DC: National Academy Press.

Brown, A. L. (1992). Design experiments: Theoretical and methodological challenges in creating complex interventions in classroom settings. *The Journal of the Learning Sciences*, 2(2), 141–178.

Buehl, M. M., Alexander, P. A., & Murphy, P. K. (2002). Beliefs about schooled knowledge: Domain specific or domain general? *Contemporary Educational Psychology*, 27(3), 415–449.

Cazden, C. B. (2001). *Classroom discourse* (2nd edition). Portsmouth, NH: Heinemann.

Cazden, C. B., & Beck, S. W. (2003). Classroom discourse. In A. C. Graesser, M. A. Gernsbacher, & S. R. Goldman (Eds.), *Handbook of discourse processes* (pp. 165–197). Mahwah, NJ: Lawrence Erlbaum.

Chandler, M., Boyes, M., & Ball, L. (1990). Relativism and stations of epistemic doubt. *Journal of Experimental Child Psychology*, 50, 370–395.

Chandler, M., Hallett, D., & Sokol, B. W. (2002). Competing claims about competing knowledge claims. In B. K. Hofer & P. R. Pintrich (Eds.), Personal epistemology: The psychology of beliefs about knowledge and knowing (pp. 145–168). Mahwah, NJ: Erlbaum.

Cole, M. (1996). *Cultural psychology: A once and future discipline*. Cambridge, MA: Harvard University Press.

Darder, A., Baltodano, M., & Torres, R. D. (Eds.) (2003). *The critical pedagogy reader*. New York: RoutledgeFalmer.

Derrida, J. (1978). *Writing and difference* (A. Bass, Trans.). Chicago, IL: University of Chicago Press.

Desimpelaere, P., Sulas, F., Duriez, B., & Hutsebaut, D. (1999). Psycho-epistemological styles and religious beliefs. *International Journal for the Psychology of Religion*, 9(2), 125–137.

Doyle, W. (1983). Acadmic work. *Review of Educational Research*, 53(2), 159–199.

Duranti, A. (1997). *Linguistic anthropology*. Cambridge: Cambridge University Press.

Gee, J. P. (1996). *Social linguistics and literacies: Ideology in discourses (Critical perspectives on literacy and education)* (2nd edition). London: Taylor & Francis.

Gergen, K. J. (1991). *The saturated self*. New York: Basic Books.

Giroux, H. A. (2001). *Theory and resistance in education*. Westport, CT: Bergin & Garvey.

Gottlieb, E. (2006). Development of religious thinking. *Religious Education*, 101(2), 242–260.

Gottlieb, E. (2007). Learning how to believe: Epistemic development in cultural context. *Journal of the Learning Sciences*, 16(1), 5–36.

Gutierrez, K., & Rogoff, B. (2003). Cultural ways of learning: Individual traits or repertoires of practice. *Educational Researcher*, 32(5), 19–25.

Hammer, D., & Elby, A. (2002). On the form of a personal epistemology. In B. K. Hofer & P. R. Pintrich (Eds.), *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 169–190). Mahwah, NJ: Lawrence Erlbaum.

Hofer, B. K. (2000). Dimensionality and disciplinary differences in personal epistemology. *Contemporary Educational Psychology*, 25, 378–405.

Hofer, B. K. (2001). Personal epistemology research: Implications for learning and teaching. *Journal of Educational Psychology Review*, 13(4), 353–383.

Hofer, B. K., & Pintrich, P. R. (1997). The development of epistemological theories: Beliefs about knowledge and knowing and their relation to learning. *Review of Educational Research*, 67(1), 88–140.

Hogan, K. (1999). Relating students' personal frameworks for science learning to their cognition in collaborative contexts. *Science Education*, 83, 1–32.

Hogan, K. (2000). Exploring a process view of students' knowledge about the nature of science. *Science Education*, 84, 51–70.

Holland, D. (1998). *Identity and agency in cultural worlds*. Cambridge, MA: Harvard University Press.

Irigaray, L. (1985). *This sex which is not one* (C. Porter & C. Burke, Trans.). Ithaca, NY: Cornell University Press.

Jackson, P. (1968). *Life in classrooms*. New York: Holt (Rinehart & Winston).

Khishfe, R., & Abd-El-Khalick, F. (2002). Influence of explicit and reflective versus implicit inquiry-oriented instruction in sixth graders' views of nature of science. *Journal of Research in Science Teaching*, 39(7), 551–578.

King, P. M., & Kitchener, K. S. (1994). *Developing reflective judgment: Understanding and promoting intellectual growth and critical thinking in adolescents and adults*. San Francisco, CA: Jossey-Bass.

King, P. M., Kitchener, K. S., Davison, M. L., Parker, C., & Wood, P. K. (1983). The justification of beliefs in young adults: A longitudinal study. *Human Development*, 26, 106–116.

Koballa, T. R. (1995). Children's attitudes toward learning science. In S. M. Glynn & R. Duit (Eds.), *Learning science in the schools: Research reforming practice*. Mahwah, NJ: Lawrence Erlbaum.

Kuhn, D. (1991). *The skills of argument*. New York: Cambridge University Press.

Kuhn, D., Cheney, R., & Weinstock, M. (2000). The development of epistemological understanding. *Cognitive Development*, 15, 309–328.

Kuhn, D., Weinstock, M., & Flaton, R. (1994). How well do jurors reason? Competence dimensions of individual variation in a juror reasoning task. *Psychological Science*, 5(5), 289–296.

Leadbeater, B., & Kuhn, D. (1989). Interpreting discrepant narratives: Hermeneutics and adult cognition. In J. Sinnott (Ed.), *Everyday problem solving* (pp. 175–190). New York: Praeger.

LeCompte, M. (1978). Learning to work: The hidden curriculum of the classroom. *Anthropology & Education Quarterly*, 9(1), 22–37.

Lee, O. (2003). Equity for linguistically and culturally diverse students in science education: A research agenda. *Teachers College Record*, 105(3), 465–489.

Lemke, J. L. (1990). *Talking science: language, learning, and values*. Norwood, NJ: Ablex.

Lyotard, J. F. (1984). *The postmodern condition: A report on knowledge*. Minneapolis, MN: University of Minnesota Press.

Magolda, M. B. B. (1992). *Knowing and reasoning in college: Gender-related patterns in students' intellectual development*. San Francisco, CA: Jossey-Bass.

Martin, J. E., Silva, D. G., Newman, J. H., & Thayer, J. T. (1994). An investigation into the structure of epistemological style. *Personality and Individual Differences*, 16, 617–629.

Mehan, H. (1979). *Learning lessons: Social organization in the classroom*. Cambridge, MA: Harvard University Press.

Nicholls, J. G., & Thorkildsen, T. A. (1988). Children's distinctions among matters of intellectual convention, logic, fact, and personal preference. *Child Development*, 59, 939–949.

NRC. (2000). *Inquiry and the national science education standards: A guide for teaching and learning*. Washington, DC: National Academy Press.

Nurmi, J. E. (1991). How do adolescents see their future? A review of the development of future orientation and planning. *Developmental Review*, 11(1), 1–59.

Nystrand, M. (1997). *Opening dialogue: Understanding the dynamics of language and learning in the English classroom*. New York: Teachers College Press.

Perry, W. (1970). *Forms of intellectual and ethical development in the college years*. New York: Holt.

Rogoff, B. (1993). Children's guided participation and participatory appropriation in sociocultural activity. In R. H. Wozniak & K. W. Fischer (Eds.), *Development in context: Acting and thinking in specific environments* (pp. 121–153). Hillsdale, NJ: Lawrence Erlbaum.

Rorty, R. (1979). *Philosophy and the rnirror of nature*. Princeton, NJ: Princeton University Press.

Schommer, M. (1990). Effects of beliefs about the nature of knoweldge on comprehension. *Journal of Educational Psychology*, 82, 498–504.

Schommer, M., Calvert, C., Gariglietti, G., & Bajaj, A. (1997). The development of epistemological beliefs among secondary students: A longitudinal study. *Journal of Educational Psychology*, 89, 37–40.

Schwartz, S. H. (1999). A theory of cultural values and some implications for work. *Applied Psychology: An International Review*, 48, 23–47.

Smith, C., Maclin, D., Houghton, C., & Hennessey, M. G. (2000). Sixth-grade students' epistemologies of science: The impact of school science experiences on epistemological development. *Cognition & Instruction*, 18(3), 349–422.

Songer, N. B., & Linn, M. C. (1991). How do students' views of science influence knowledge integration? *Journal of Research in Science Teaching*, 28, 761–784.

Sprinzak, D., Bar, E., Segev, Y., & Levi-Mazloum, D. (Eds.) (2004). *Ministry of education culture and sport: Facts and figures hatashsad 2004 [Hebrew]*. Jerusalem: Ministry of Education.

Strike, K. A., & Posner, G. J. (1992). A revisionist theory of conceptual change. In R. A. Duschl & R. J. Hamilton (Eds.), *Philosophy of science, cognitive psychology, and educational theory and practice* (pp. 147–176). Albany, NY: State University of New York Press.

Tabak, I., & Weinstock, M. P. (2005). Knowledge is knowledge is knowledge? The relationship between personal and scientific epistemologies. *Canadian Journal for Science, Mathematics and Technology Education*, 5(3), 307–328.

Wainryb, C. (1995). Reasoning about social conflicts in different cultures: Druze and Jewish children in Israel. *Child Development*, 66, 390–401.

Weinstock, M. (2005, August). *Grade level, gender, and ethnic differences in epistemological understanding within domains*. Paper presented at the Biennial Meeting of the European Association for Research on Learning and Instruction. Nicosia, Cyprus.

Weinstock, M. (2007, March). *Differences in epistemological understanding among Jewish- and Bedouin-Israeli adolescents*. Poster presented at the Meeting of the Society for Research in Child Development. Boston, MA.

Weinstock, M., & Cronin, M. A. (2003). The everyday production of knowledge: Individual differences in epistemological understanding and juror-reasoning skill. *Applied Cognitive Psychology*, 17, 161–181.

Wells, G. (1993). Reevaluating the IRF sequence: A proposal for the articulation of theories of activity and discourse for the analysis of teaching and learning in the classroom. *Linguistics and Education*, 5, 1–37.

Wells, G. (1999). *Dialogic inquiry: Towards a sociocultural practice and theory of education*. Cambridge: Cambridge University Press.

Wertsch, J. V. (1998). *Mind as action*. New York: Oxford University Press.

Wigfield, A., Eccles, J. S., & Rodriguez, D. (1998). The Development of children's motivation in school contexts. *Review of Research in Education*, 23, 73–118.

Chapter 9
An Exploratory Study About the Role of Epistemological Beliefs and Dispositions on Learners' Thinking About an Ill-defined Issue in Solo and Duo Problem-solving Contexts

Nicos Valanides and Charoula Angeli

Abstract This chapter examines the relationship between epistemological beliefs and dispositions and their role on ill-defined problem solving in solo and duo contexts. The results showed that different aspects of epistemological beliefs correlated significantly with some dispositions, and that solo and duo contexts triggered different aspects of the constructs, although both of them were important for ill-defined problem solving. Lastly, the findings showed that emotions were associated with some aspects of epistemological beliefs and dispositions in the duo problem-solving context only.

9.1 Introduction

Undoubtedly, today's world confronts us with tremendous amounts of information through advanced information technologies and places great demands on our personal and professional lives requiring the ability to make judgments about private, social, economic, and political issues (Beyer, 1995; Paul, 1993). Moreover, the problems that we are confronted with, either in our daily lives or in the workplace, are mostly ill defined, that is, problems for which there is real uncertainty as to how they can best be solved.

The ability to think about ill-defined problems is contingent upon one's argumentation skills (Elstein et al., 1978). Jonassen (1996, 1997, 2000) further explains that ill-defined problems have vague goals, unspecified constraints and multiple possible solutions that need to be considered and evaluated based on criteria before a specific solution is proposed as the best possible one. Thus, "the nature of these ill-structured problems is such that neither analysis nor solutions are 'true' or 'false': they are the result of an argumentative process in which participants eventually reach an agreement on a common analysis and a solution, that may be 'good' or 'bad' " (van Bruggen & Kirschner, 2003, p. 177).

University of Cyprus, Nicosia, Cyprus

M. S. Khine (ed.), *Knowing, Knowledge and Beliefs: Epistemological Studies across Diverse Cultures.*

9.2 Review of the Literature

Mayer (1998) claims that problem solving is directed mainly toward cognitive processes. Clearly, problem solving requires cognitive and metacognitive processes, however, as Oh and Jonassen (in press) argue, cognitive processes are necessary but insufficient requirements for solving problems, especially ill-defined problems, for which learners' dispositions and beliefs about knowledge and how it develops, i.e., epistemological beliefs, seem to affect the ways that learners naturally tend to approach problems.

Researchers (Cacciopo & Petty, 1982; Facione & Facione, 1992; Facione et al., 1994; Facione et al., 1995; McBride et al., 2002; Langer, 1989; Perkins et al., 1993; Perkins et al., 2000) state that intelligence in everyday circumstances, in which carefully framed tests do not tell people exactly what to decide or do, depends in considerable part on thinking dispositions – that is on what people are disposed or habituated to do – and not only on skills and abilities. Perkins et al. (1993) argue that a dispositional view of intelligence is strongly warranted and constitutes an important area for continued research, because dispositions are more stable traits that contribute to intellectual performance.

Facione et al. (1996) defined dispositions as the consistent internal motivation to employ one's abilities in judging what to believe or do in any situation. They also proposed seven components of dispositions, namely, (a) Open-mindedness, (b) Analycity, (c) Truth-seeking, (d) Systematicity, (e) Self-confidence, (f) Inquisitiveness, and (g) Maturity. Open-mindedness refers to the disposition of being tolerant of divergent views. Analycity is the disposition of being alert to potentially problematic situations anticipating possible results or consequences. Truth-seeking is the disposition of being eager to seek the truth and be objective about asking questions. Systematicity refers to a disposition toward organized, orderly and focused inquiry. Self-confidence determines the level of trust one places in one's own reasoning processes. Inquisitiveness refers to intellectual curiosity, while maturity determines how disposed a person is to make reflective judgments.

Research by Perkins et al. (1986) showed that if learners do not believe in their ability to solve problems, they will most likely not exert sufficient mental effort and thus they will not succeed. Thus, learners' self-confidence of ability to tackle difficult problems can predict the level of effort and perseverance they will apply in order to solve the problem. Greeno (1991) also found that task persistence and effort are strong predictors of problem-solving success. Moreover, according to Hare (2003), "if we take seriously the notion of genuine inquiry, together with such related ideas as considering all sides to a question, paying attention to counter-evidence, viewing one's conclusions as provisional, learning from one's mistakes, and trying to rid oneself of bias, then the attitude of open-mindedness immediately presents itself as having fundamental significance" (p. 5). After all, to be open-minded is to be critically receptive to alternative possibilities, to be willing to think again, despite having formulated a view, and to be concerned enough to defuse any factors that constrain one's thinking in predetermined ways (Hare, 2003).

Recently, few research studies (Sinatra et al., 2003; Kardash & Sinatra, 2003) have attempted to show that both epistemological beliefs and dispositions affected the ways that learners approached the solution of problems and the results showed that the scores on the dispositional scales correlated significantly with the scores on the epistemological beliefs scales. In particular, Kardash and Sinatra (2003) showed that there was a considerable overlap among the constructs measured by epistemological belief scales and disposition scales, but, their data also showed that there were some important distinctions between them. In particular, their data suggested that dispositions instruments tend to measure individuals' tendencies and commitments, whereas epistemological beliefs focus more on individuals' perspectives about learning and knowledge. Sinatra et al.'s (2003) research findings underscore the significance of epistemological beliefs and dispositions in the learning of potentially controversial topics.

Research demonstrating the role of epistemological beliefs in learning can be traced back to the work of Perry (1970). Perry's work showed that while college freshmen tended to believe in simple, certain knowledge that is handed down by authority, by the time they reached their fourth year in college they changed their beliefs and believed more in tentative, complex knowledge derived from reason. In 1990, 20 years after Perry's work, Schommer reported on a study attempting to test the conceptualization of epistemological beliefs as a system of more or less independent beliefs. In essence, Schommer's (1990, 1998) work distinguished between unidimensional and multidimensional models of epistemological development proposing that probably not all beliefs develop at the same rate. This approach suggests that, at some point in time, an individual may come to believe that knowledge is highly interrelated, but yet also believe that knowledge is certain. In particular, Schommer (1994) proposed a taxonomy of five dimensions of epistemological beliefs, namely (a) beliefs about the stability of knowledge, ranging from tentative to unchanging, (b) beliefs about the structure of knowledge, ranging from isolated bits to integrated concepts, (c) beliefs about the source of knowledge, ranging from handed down by authority to assemble from observation and reason, (d) beliefs about the speed of knowledge acquisition, ranging from quick-all-or-none learning to gradual learning, and (e) beliefs about the control of knowledge acquisition, ranging from fixed at birth to lifelong improvement. In order to assess these beliefs, Schommer (1990) constructed a questionnaire with 63 Likert-type items on a scale from 1 (strongly disagree) to 5 (strongly agree). Exploratory factor analyses confirmed four of the five beliefs that Schommer hypothesized, namely, stability and structure of knowledge and speed and control of learning.

Research by Bendixen et al. (1994) showed that students who view ability as innate and thus fixed may be less inclined to pursue challenging intellectual experiences or tackle intellectual tasks strategically and so may be less inclined to develop and use advanced reasoning skills when thinking about ill-defined issues. Also research by Schraw et al. (1995) found that well-structured and ill-structured problems engaged different epistemological beliefs. Individuals who view knowledge from a relativistic perspective adopted multiple strategies to analyze contradiction and ambiguity on ill-structured problems. More research findings also showed that epistemological beliefs affect the quality of written arguments about an ill-defined problem (Bendixen & Schraw 2001; Schommer & Dunnell, 1997). Schommer and Dunnell (1997) found that the more students believed that the ability to learn is fixed at birth, that learning is quick or not-at-all, and that knowledge is unchanging, the more likely they wrote overly simplistic solutions to problems.

9.3 Research Questions

A question that could be asked at this point is whether different research results could be obtained if sociocultural aspects of learning were taken into consideration in all of the aforementioned research studies. We believe this is a very important question that needs to be investigated, because more and more people seem to form partnerships and think with others and with the help of tools and artifacts, and thus it has become widely accepted that cognitions are not decontextualized tools and products of mind, but situated and distributed. In spite of this, epistemological beliefs, as well as reasoning and dispositions, like many other psychological constructs, have mainly been viewed and studied as constructs that have been developed in psychology and focused primarily on individual cognition. More specifically, research has not addressed closely the role of social context on one's epistemic beliefs. In other words, could it be possible for Bendixen, Schraw, Schommer, and Dunnell to obtain different results about the role of epistemological beliefs on students' reasoning had they asked their students to think about an ill-defined problem, not alone, but with others in a collaborative setting? Will an individual's epistemic beliefs behave the same way if he thinks about a problem alone or with others in a collaborative environment? The same of course could be asked about reasoning skills and dispositions.

Therefore, in this study, we considered sociocultural aspects of the context within which thinking occurred, and examined the relationships among epistemological beliefs, reasoning, and dispositions when research participants first thought about an ill-defined problem alone, and then with another person in a dyad using a text-based computer supported collaborative environment. More specifically, this research study sought to answer the following questions:

1. What is the relationship between students' dispositions and epistemological beliefs?
2. What are the elements of students' reasoning when thinking about an ill-defined problem in solo and duo problem-solving contexts?
3. What is the relationship between students' epistemological beliefs and students' elements of reasoning when thinking about an ill-defined problem in solo and duo problem-solving contexts?
4. What is the relationship between students' dispositions and students' elements of reasoning when thinking about an ill-defined problem in solo and duo problem-solving contexts?

9.4 Method

9.4.1 Participants

Eighteen graduate students from a teacher education department volunteered to participate in the study. Of the 18 students, 7 were males and 11 females. The average age of the participants was 25.22 years. Two of the participants were pursuing a master's degree in Science Education, two in Mathematics Education, two in Educational Sciences, and the rest of them in Curriculum and Instruction.

9.4.2 Instruments

9.4.2.1 The California Critical Thinking Dispositions Inventory

The California Critical Thinking Dispositions Inventory (CCTDI) was used to assess participants' dispositions (Facione et al., 1995, 1996). The CCTDI is composed of seven subscales and contains 75 6-point Likert-type items. The scores for some test items range from "strongly disagree" (score of 1) to "strongly agree" (score of 6); for others they range from "strongly agree" (score of 1) to "strongly disagree" (score of 6). Each of the seven subscales, corresponding to the seven dispositional aspects toward critical thinking, is composed of 9–12 items that are spread throughout the instrument. The seven subscales include the dispositions of (a) Truth-seeking, (b) Open-mindedness, (c) Analycity, (d) Systematicity, (e) Self-confidence, (f) Inquisitiveness, and (g) Maturity. Specifically, (1) Truth-Seeking (T-scale): It targets the disposition of being eager to seek the truth, to ask questions, and to being objective and honest about pursuing inquiry, even though the findings may not support one's preconceived points of view. (2) Open-mindedness (O-scale): It targets the disposition of being open-minded and tolerant of deviant views while one is aware of his or her biases. (3) Analycity (A-scale): It targets the disposition of being alert to potentially problematic situations anticipating possible results or consequences. The analytically inclined person constantly looks for effective ways to resolve problems. (4) Systematicity (S-scale): It targets the disposition toward organized, focused, orderly, and hard-working inquiry when working with complexity. (5) Self-Confidence (C-scale): It refers to the level of trust one places on his or her reasoning processes. Self-confident people trust themselves to make good judgments and believe that others trust them as well. (6) Inquisitiveness (I-scale): It measures one's intellectual curiosity. The inquisitive person is one who values being well informed, wants to know how things work, and values learning even when the payoff is not directly evident. (7) Maturity (M-scale): It measures how disposed a person is to make reflective judgments. The maturity scale addresses both cognitive maturity and epistemic maturity – that is, it targets the disposition to approach problems, inquiry, and decision-making with a sense that some problems are ill defined, and that many times judgments based on standards, context, and evidence, which inhibit certainty, must be made.

The CCTDI is designed to be used with university students and includes eight scores, namely, seven subscale scores and an overall CCTDI score. Scores on the seven CCTDI subscales can range from 10 to 60. A score of 40 or higher indicates a confirmation of the scale's characteristic and a score of 30 or lower indicates a disinclination or hostility toward the same characteristic. Any intermediate score lower than 40 but higher than 31 indicates ambivalence (Facione & Facione, 1992). A total CCTDI score of 210 or lower indicates a negative overall disposition toward critical thinking, whereas a score lower than 280 but higher than 210 shows a serious deficiency in the overall disposition toward critical thinking. Finally, a total CCTDI score of 350 or greater constitutes a solid indication of across-the-board strength in the disposition toward critical thinking (Facione & Facione, 1992; Facione et al., 1995). Cronbach's alpha internal consistency reliabilities for the seven dispositions were found to range from .71 to .80, and the alpha reliability for the overall instrument measuring the overall disposition toward critical thinking was found to be .91 (Facione & Facione, 1992).

9.4.2.2 Epistemological Beliefs Questionnaire

Schommer's (1990, 1994) epistemological beliefs questionnaire was used to assess participants' epistemological beliefs. The questionnaire consists of 63 short statements that students rate on a Likert scale from 1 (strongly disagree) to 5 (strongly agree). The 63 statements represent 12 subsets of epistemological beliefs scales namely, Seek single answers, Avoid integration, Avoid ambiguity, Knowledge is certain, Don't criticize authority, Depend on authority, Can't learn how to learn, Success is unrelated to hard work, Ability to learn is innate, Learning is quick, Learn first time, and Concentrated effort is a waste of time. Schommer hypothesized that these 12 subscales form five different dimensions of epistemological beliefs namely, knowledge is simple, certain and handed down by authority, learning is quick and ability to learn is fixed (or innate). According to Schommer these five beliefs exist on a continuum from naïve to sophisticated and it is possible for students to be naïve in some of these dimensions and more sophisticated in others.

Both exploratory and confirmatory factor analyses, using the 12 subsets of items as input variables, have produced a consistent four-factor structure, rather than the five-factor structure predicted. The four factors are (1) Ability to learn is innate (Innate Ability), (2) Knowledge is discrete and unambiguous (Simple Knowledge), (3) Learning is quick or not at all (Quick Learning), and (4) Knowledge is certain (Certain Knowledge). The dimension that did not emerge from the factor analyses was Omniscient Authority.

9.4.3 Research Procedures

Data were collected in three research sessions. During the first research session, which lasted for 40 min, participants completed the California Critical Thinking Dispositions Inventory and then Schommer's test. Each test was administered in 20 min.

Seven days after the first research session, the second research session took place. In the second research session, which lasted for 60 min, participants were first given 20 min to read some materials about the history of Cyprus and the Annan plan. Then, for the next 40 min, they were asked to work individually and write, using a text-based computer-mediated tool, their position on the issue regarding the reunification of Cyprus on the basis of the Annan Plan. Students were given written instructions and were specifically asked to analyze the issue broadly from different perspectives and support with reason and evidence their own position on the issue.

Seven days later, the third research session took place. During the third research session, which lasted for 40 min, students were randomly assigned into dyads. Students in each dyad were instructed to discuss the issue, regarding the reunification of Cyprus on the basis of the Annan Plan, together, using a synchronous text-based computer-supported collaborative environment that was specifically designed and developed for the purposes of this study. Students in each dyad remained anonymous during the session and were accommodated in two different rooms to also eliminate any physical contact between them. As it was the case with the second research session, students in the third session were also given written instructions asking them to analyze the issue broadly from different perspectives and support with reason and evidence their position on the issue. Students could also use the reading materials any time they wanted during the third research session.

9.5 Results

9.5.1 Learners' Dispositions and Epistemological Beliefs

Table 9.1 shows participants' mean scores on each dispositional scale and their total CCTDI scores. Higher scores on the dispositional scales indicate higher levels of the disposition being measured. As it is shown in Table 9.1, participants' performance on the T-scale of the CCTDI was better than their performance on the other subscales of the test with a mean score of 38.99 (SD = 9.53). Participants' mean scores on the S-scale and O-scale were 30.22 (SD = 6.15) and 32.61 (SD = 6.24), respectively, while participants' mean scores on the other four scales were less than 30. Also, as Table 9.1 shows, the mean of the total CCTDI scores was found to be 194.44 (SD = 28.51), which indicates disinclination toward critical thinking.

Concisely, the results support the conclusion that the participants of the present study had more favorable dispositions toward truth-seeking, less favorable dispositions toward systematicity and open-mindedness, and disinclination toward analycity, confidence, maturity, and inquisitiveness. Also, their total CCTDI scores indicated a negative disposition toward critical thinking.

Table 9.2 shows participants' mean scores on each of the twelve scales of epistemological beliefs as they were measured using Schommer's (2000) epistemological beliefs instrument. Due to the fact that the number of participants in this study was small, it was not possible to conduct exploratory factor analyses or confirmatory factor analyses in

Table 9.1 Descriptive statistics of learners' scores on the dispositional scales (n = 18)

	Mean	*SD*
Truth-seeking	38.99	9.53
Open-mindedness	32.61	6.24
Analycity	23.72	5.71
Systematicity	30.22	6.15
Self-confidence	19.72	5.23
Inquisitiveness	22.28	6.73
Maturity	29.50	6.43
Total	196.44	28.51

Table 9.2 Descriptive statistics of learners' scores on the epistemological beliefs scales (n = 18)

Scale	Mean	*SD*
Seek single answers	2.75	.32
Avoid integration	2.43	.32
Avoid ambiguity	2.88	.68
Knowledge is certain	2.22	.55
Depend on authority	2.64	.37
Don't criticize authority	2.31	.43
Ability to learn is innate	2.14	.83
Can't learn how to learn	2.02	.34
Success is unrelated to hard work	2.19	.50
Learn the first time	1.94	.76
Learning is quick	2.22	.64
Concentrated effort is a waste of time	1.97	.55

order to compare factor scores with those reported in Schommer's (1999, 1994, 2000) research. We also considered it inappropriate to accept the factors reported by Schommer (2000) without hesitation since there is research evidence showing that in different cultural contexts, items on Schommer's questionnaire did not load into the same factors reported in her studies (Chan, 2000). For these reasons, in all of the analyses we conducted for the purposes of this study, we used the mean scores on the 12 subscales of epistemological beliefs, namely, Seek single answers, Avoid integration, Avoid ambiguity, Knowledge is certain, Depend on authority, Don't criticize authority, Ability to learn is innate, Can't learn how to learn, Success is unrelated to hard work, Learn the first time, Learning is quick, and Concentrated effort is a waste of time.

9.5.2 The Relationship Between Learners' Dispositions and Epistemological Beliefs

Table 9.3 shows Pearson *r* correlations between participants' dispositions and epistemological beliefs. As one would expect theoretically, scores on the epistemological beliefs scales correlated significantly with scores on the dispositional scales.

Table 9.3 Correlations between dispositions and epistemological beliefs (n = 18)

Epistemological beliefs scales	Dispositional scales						
	Truth-seeking	Open-mindedness	Analyticity	Systematicity	Self-confidence	Inquisitiveness	Maturity
Seek single answers	.46	.30	.02	−.13	−.30	−.16	.19
Avoid integration	−.22	−.16	.29	−.21	.14	.17	.14
Avoid ambiguity	.34	.39	.18	−.36	.11	−.02	.47*
Knowledge is certain	−.20	.23	−.34	−.48*	−.08	−.34	−.44
Depend on authority	.30	−.07	.15	.38	.01	−.07	.03
Don't criticize authority	.51*	.38	−.04	.32	−.23	−.25	.39
Ability to learn is innate	.63**	.28	.40	.20	−.02	.27	.52*
Can't learn how to learn	−.13	.20	.32	−.17	.39	.26	.04
Success is unrelated to hard work	.44	.05	.27	.71**	−.06	.14	.28
Learn the first time	.57*	.48*	.62**	.06	.29	.43	.42
Learning is quick	.69**	.43	.27	.63**	.15	.45	.60**
Concentrated effort is a waste of time	−.04	−.13	.68**	.17	.14	.29	−.12

* Significant at $p < .05$.
** Significant at $p < .01$.

Higher scores on the dispositions Truth-seeking, Open-mindedness, and Analycity were associated with more sophisticated beliefs on the scale Learn the first time, with correlations $r = .57$ ($p < .05$), $r = .48$ ($p < .05$), and $r = .62$ ($p < .01$) respectively. Also, higher scores on the epistemological beliefs scale Learning is quick were correlated significantly with more advanced tendencies toward Truth-seeking, Systematicity, and Maturity, with correlations $r = .69$ ($p < .01$), $r = .63$ ($p < .01$), and $r = .60$ ($p < .01$) respectively. More advanced sophisticated beliefs on the scale Ability to learn is innate were significantly correlated with higher scores on the dispositions Truth-seeking ($r = .63$, $p < .01$) and Maturity ($r = .52$, $p < .05$). Moreover, higher scores on the epistemological beliefs scale Avoid ambiguity were correlated with higher scores on the disposition Maturity ($r = .47$, $p < .05$), higher scores on the epistemological beliefs scale Don't criticize authority were correlated with the disposition Truth-seeking ($r = .51$, $p < .05$), Success is unrelated to hard work was correlated with the disposition Systematicity ($r = .71$, $p < .01$), Concentrated effort is a waste of time was correlated with the disposition Analycity ($r = .68$, $p < .01$), and Knowledge is certain was negatively correlated with the disposition Systematicity ($r = -.48$, $p < .05$).

9.5.3 The Elements of Thinking in Solo and Duo Problem-solving Contexts

A coding scheme was constructed inductively using grounded theory to reveal the elements of students' reasoning when thinking about an ill-defined issue alone and in a dyad (Corbin & Strauss, 1990; Strauss & Corbin, 1990). According to the methodology of grounded theory, coding for emerging concepts is done by close examination of the data, with the intention of developing core categories that account for most of the variance in the data. The aim of coding is to arrive at systematically derived core categories, and their properties, that become the focal concepts that contribute toward theoretical development. The methodology of grounded theory identified 19 different elements of thought, and these are shown along with their descriptions in Table 9.4. Also, Table 9.5 shows specific examples for each type of element so that the reader better understands the differences between the various elements of students' thinking.

A first version of the coding scheme was inductively constructed by the two researchers and it was then given to an independent rater for confirmation. The independent rater and the researchers discussed all discrepancies and an improved version of the coding scheme was prepared. Then two other independent raters analyzed all solo and duo transcripts and a Pearson r between the two ratings was calculated and found to be 0.81, which was regarded satisfactory considering the complexity of the data. The two raters and the researchers discussed any observed disagreements and resolved after discussion the existing differences.

As shown in Table 9.6, the average number of elements when students thought about the problem alone was 16.39 ($SD = 9.92$), but when students were put into

Table 9.4 Elements of thinking and descriptions

Elements	Description
Information from reading materials	Information present in the reading materials provided to learners.
Cultural identity	Knowledge that is directly or indirectly related to, and could only be known from, the learner's culture, as defined by his or her cultural identity. This includes stories, historical events, or experiences that are passed on from generation to generation, through interactions that are directly related to their country.
Emotion	Knowledge, experience, event, or activity that is either directly or indirectly emotionally charged, defined by the learner's choice of a word, phrase or clause, and/or the presence of a punctuation of unit.
Information from personal experience	Knowledge, experience, activity, or event that is derived from the individual's personal experience, activity, or from the experiences of his/her extended family.
Information from other sources	Knowledge, experience, activity, or event that is not directly or personally related to, and was not present in the materials provided. This information has no influence on cultural identity.
Inference	Knowledge in the form of "if x, then y", based upon one or more units either of information contained in the materials or knowledge from the learner/s.
Value judgment not supported by evidence	An evaluative statement, belief, judgment, preference, desire, opinion or suggestion expressed by the learner that is clearly judgmental but is not justifiable by any form of knowledge.
Value judgment supported by evidence in the form of information given in the reading materials	An evaluative statement, belief, judgment, opinion or suggestion expressed by the learner that is clearly judgmental but is also supported by evidence provided in the reading materials.
Value judgment supported by evidence in the form of cultural identity	An evaluative statement, belief, judgment, opinion or suggestion expressed by the learner that is clearly judgmental but is also supported by evidence derived from cultural identity.
Value judgment supported by evidence in the form of an emotion.	An evaluative statement, belief, judgment, opinion or suggestion expressed by the learner that is clearly judgmental but is also supported by evidence grounded on one's emotions
Value judgment supported by evidence in the form of personal experience	An evaluative statement, belief, judgment, opinion or suggestion expressed by the learner that is clearly judgmental but is also supported by evidence provided from personal experiences.
Value judgment supported by evidence in the form of information from other sources	An evaluative statement, belief, judgment, opinion or suggestion expressed by the learner that is clearly judgmental but is also supported by evidence provided in information given by other sources.
Question to elicit information	Information questions are objective and have a specific factual answer.
Evaluative question	Evaluative questions are subjective and are like a judgment call.
Hypothetical question	A question of what could/would happen.
Clarifying question	A question that asks for clarification.
Social acknowledgment	All statements or questions that are social greetings or responses.
Personal data	Personal data.
Clarification	Whatever the learner clarified for the other learner.

Table 9.5 Elements of thinking in solo and duo problem-solving contexts

Elements	Code	Example
Information from reading materials	Inf(M)	On the basis of the Annan plan, Britain would keep the military bases and gain control of part of the coast line and its natural recourses in the water.
Cultural identity	CId	The invasion of 1974 has created a lot of turmoil in the relationship between the Greek-Cypriots and the Turkish-Cypriots.
Emotion	E	The memories are alive!!! We deserve it!!!!
Information from personal experience	PE	My grandparents are now dead and they did not return to their homes…that was their only wish…to return to their homes before dying…
Information from other sources	OS	Yes both communities suffered from the consequences of the war in 1974.
Inference	Inference	If an internal political disagreement occurred in the new Cyprus government, the solution would be given by a court consisting of three Greeks, three Turks and three foreign judges.
Value judgment not supported by evidence	VJ	A sort of coexistence should take place BEFORE any other political solutions are given.
Value judgment supported by evidence in the form of information given in the reading materials	VJ(M)	Another reason for believing that the Annan plan is not suitable for Cyprus is that it sets a complex rotating system of presidency, with president a Greek and vice president a Turkish, changing roles every 20 months.
Value judgment supported by evidence in the form of cultural identity	VJ(CId)	People of Cyprus, both Turkish-Cypriots and Greek-Cypriots have managed to coexist for many years. That is why I believe that any matter of a difference in a religion or culture can be overcome.
Value judgment supported by evidence in the form of an emotion	VJ(E)	Turkish students need to also learn that Greek-Cypriots are humans too… that they are still suffering and that both sides have made mistakes!!
Value judgment supported by evidence in the form of personal experience	VJ(PE)	As far as I am concerned, nothing can erase from my parent's memory the incidents that they have experienced throughout the Turkish invasion. I think that my parents definitely think about them and I know that my grandparents cannot forget them. Consequently, the memories of these wounds have affected their decision about voting for or against the Annan plan.
Value judgment supported by evidence in the form of information from other sources	VJ(OS)	I do not know much about political issues, but I think that the fact that the United Nations and Britain exerted influence over the Greek-Cypriots to accept the Annan plan was not that good.
Question to elicit information	Q(I)	What do you believe about the Annan plan?
Evaluative question	Q(E)	Don't you think that the two communities need to mix in a different way?

(continued)

Table 9.5 (continued)

Elements	Code	Example
Hypothetical question	Q(H)	What could happen if the Annan plan was implemented?
Clarifying question	Q(Cl)	Are you talking about the court that will decide about a matter if we cannot reach a solution?
Social acknowledgment	SA	Hi!
Personal data	PD	I am a refugee.
Clarification	Clarification	Yes, that is what I said.

Table 9.6 Mean frequencies and standard deviations for the elements of thinking in solo and duo problem-solving contexts (n = 18)

	Solo			Duo		
Element code	Frequency	Mean	*SD*	Frequency	Mean	*SD*
Inf(M)	20	1.11	1.88	14	.78	1.48
CId	1	.06	.24	0	.00	.00
E	2	.11	.32	6	.33	.69
PE	0	.00	.00	2	.11	.32
OS	4	.22	.55	12	.67	1.24
Inference	9	.50	.79	27	1.50	1.50
VJ	115	6.39	6.84	218	12.11	6.00
VJ(M)	84	4.67	2.52	30	1.67	1.57
VJ(CId)	8	.44	.62	12	.67	.84
VJ(E)	0	.00	.00	8	.44	.71
VJ(PE)	1	.06	.24	1	.06	.24
VJ(OS)	40	2.22	2.10	58	3.22	2.26
Q(I)	0	.00	.00	66	3.67	2.33
Q(E)	6	.33	.97	43	2.39	2.40
Q(H)	3	.17	.51	1	.06	.24
Q(Cl)	0	.00	.00	7	.39	.70
SA	1	.06	.24	75	4.17	2.80
PD	1	.06	.24	7	.39	.80
Clarification	0	.00	.00	6	.33	.77
Total	295	16.39	9.92	595	33.06	13.16

dyads and were asked to think about the problem with another person the average number of elements per student increased dramatically to 33.06 (*SD* = 13.16). Also as shown graphically in Fig. 9.1, solo thinking was more likely to include value judgments not supported by evidence (*Mean* = 6.39, *SD* = 6.84), value judgments supported by evidence in the form of information given in the reading materials (*Mean* = 4.67, *SD* = 2.52), value judgments supported by evidence in the form of information from other sources (*Mean* = 2.22, *SD* = 2.10), information from reading materials (*Mean* = 1.11, *SD* = 1.88), inferences (*Mean* = .50, *SD* = .79), and value judgments supported by evidence in the form of cultural identity (*Mean* = .44, *SD* = .62).

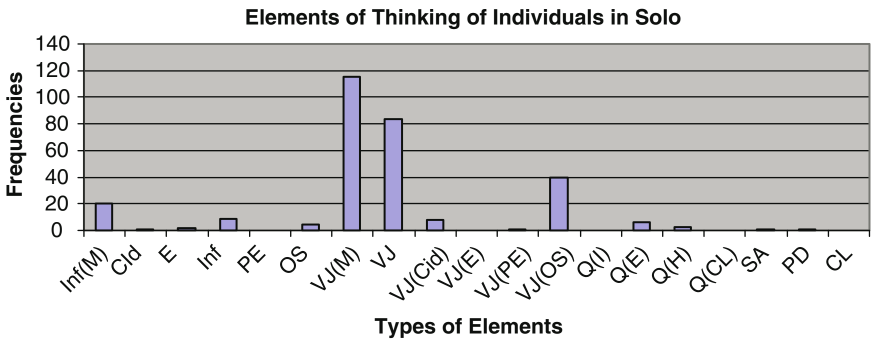


Fig. 9.1 Frequencies of elements of thinking when students think alone

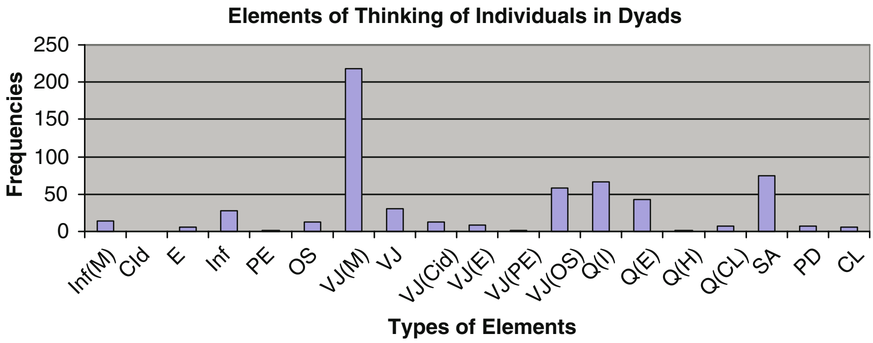


Fig. 9.2 Frequencies of elements of thinking when students think in dyads

Similarly, the elements of an individual's thinking when he or she thought about the problem in a group setting, as shown in Fig. 9.2, was more likely to include value judgments not supported by evidence (*Mean* = 12.11, *SD* = 6.00), social acknowledgment (*Mean* = 4.17, *SD* = 2.80), questions asking for information (*Mean* = 3.67, *SD* = 2.33), value judgments supported by evidence in the form of information from other sources (*Mean* = 3.22, *SD* = 2.26), evaluative questions (*Mean* = 2.39, *SD* = 2.40), value judgments supported by evidence in the form of information given in the reading materials (*Mean* = 1.67, *SD* = 1.57), inferences (*Mean* = 1.50, *SD* = 1.50), information from reading materials (*Mean* = .78, *SD* = 1.48), value judgments supported by evidence in the form of cultural identity (*Mean* =.67, *SD* = .84), and value judgments supported by evidence in the form of an emotion (*Mean* = .44, *SD* = .71).

Repeated measures analyses of variance were subsequently conducted to detect any significant differences between the number of elements of students' reasoning when thinking alone and in a dyad. According to the analyses, significant within-subject effects were found for seven elements, namely, Inference (F = 5.23, p < .05), Value judgments not supported by evidence

($F = 25.32$, $p < .01$), Value judgments supported by evidence in the form of information given in the reading materials ($F = 12.79$, $p < .01$), Value judgments supported by evidence in the form of an emotion ($F = 8.00$, $p < .05$), Evaluative questions ($F = 13.83$, $p < .01$), Social acknowledgment ($F = 119.04$, $p < .01$), and Clarification ($F = 9.00$, $p < .05$).

9.5.4 The Relationship Between Dispositions and Elements of Thinking in Duo Problem-solving Contexts

Table 9.7 shows Pearson *r* correlations between learners' dispositions and elements of thinking in the context of problem solving in a dyad. Due to the fact that all correlations between dispositions and elements of thinking in solo contexts were found to be insignificant, they are not shown in the Table. As shown in Table 9.7, the dispositional scale of Open-mindedness was correlated with Emotion ($r = .50$, $p < .05$), Analycity was correlated with Value judgments not supported by evidence ($r = .51$, $p < .05$), Self-confidence was correlated with Value judgments not supported by evidence ($r = .55$, $p < .05$), and Inquisitiveness was correlated with both Personal experiences ($r = .55$, $p < .05$) and Personal data ($r = .48$, $p < .05$).

9.5.5 The Relationship Between Epistemological Beliefs and Elements of Thinking in Solo and Duo Problem-solving Contexts

Table 9.8 shows Pearson *r* correlations between learners' epistemological beliefs and elements of thinking in solo and duo problem-solving contexts. As shown in Table 9.8, in the solo problem-solving context, scores on the epistemological beliefs scale Ability to learn is innate were negatively correlated with the element of Cultural identity ($r = -.49$, $p < .05$), higher scores on the epistemological belief Can't learn how to learn were correlated with Cultural Identity ($r = .58$, $p < .05$), and Success is unrelated to hard work was correlated with both Information from other sources ($r = .53$, $p < .05$), and Value judgment supported by evidence in the form of information from other sources ($r = .52$, $p < .05$).

Similarly, as it is also shown in Table 9.8, in the duo problem-solving context, scores on the epistemological beliefs scale Don't criticize authority were correlated with Information from other sources ($r = .61$, $p < .01$), higher scores on the epistemological belief Can't learn how to learn were correlated with both Information from materials ($r = .51$, $p < .05$), and Emotion ($r = .48$, $p < .05$), Success is unrelated to hard work was negatively correlated with Emotion ($r = -.50$, $p < .05$), and Learning is quick was negatively correlated with Value judgments supported by evidence in the form of cultural identity ($r = -.47$, $p < .05$).

Table 9.7 Correlations between elements of thinking and dispositions

	Duo problem-solving context																	
	Inf(M)	E	PE	OS	Infer.	VJ	VJ(M)	VJ(CId)	VJ(E)	VJ(PE)	VJ(OS)	Q(I)	Q(E)	Q(H)	Q(Cl)	SA	PD	Clar.
Truth-seeking	−.22	.08	−.17	.30	−.07	−.16	−.27	−.23	−.02	−.12	.12	.03	.08	−.12	.05	.10	−.20	.13
Open- mindedness	.03	.50*	−.07	.31	.07	.09	−.04	−.18	−.04	−.18	.26	.05	−.11	−.18	.16	.19	−.20	.00
Analycity	.08	.04	.24	−.21	.02	.51*	.11	.25	−.04	.28	.44	.27	−.06	.28	.46	.28	.19	−.17
Systematicity	−.03	−.19	.14	−.32	−.15	−.01	−.181	−.29	.30	.11	.17	−.10	.09	.11	−.05	.15	−.02	.28
Self-confidence	.16	.29	.44	−.28	.39	.55*	.17	.19	.12	.11	.08	.23	.10	.11	.40	.27	.23	−.03
Inquisitiveness	.20	−.03	.55*	−.41	.18	.28	.29	.04	.13	.40	.39	.18	.24	.40	.04	.07	.48*	−.04
Maturity	.05	−.01	−.31	.33	.11	−.27	−.05	−.22	−.42	.18	−.08	−.17	.19	.18	−.18	.06	−.16	−.16

*Significant at $p < .05$.

Table 9.8 Correlations between elements of thinking and epistemological beliefs

	Solo problem-solving context												
Epistemological beliefs scale	Inf(M)	CId	E	Inference	OS	VJ	VJ(M)	VJ(CId)	VJ(PE)	VJ(OS)	Q(E)	Q(H)	PD
Seek single answers	−.00	−.23	−.18	.11	.37	−.24	−.43	.11	−.02	.23	−.07	−.12	−.02
Avoid integration	.00	−.24	−.20	−.47	−.28	−.07	.10	.05	−.04	−.34	.10	.03	−.04
Avoid ambiguity	.14	−.10	−.15	−.19	−.18	.05	−.16	.14	.19	−.05	.12	.20	.19
Knowledge is certain	−.08	.35	.05	.36	−.17	.15	−.16	.18	.17	−.11	−.06	.11	.17
Depend on authority	−.30	−.44	.11	.10	.28	−.06	.07	−.36	−.10	−.00	−.43	−.29	−.10
Don't criticize authority	.39	−.09	−.26	.34	.10	−.23	.13	−.11	−.28	−.26	−.36	−.38	−.28
Ability to learn is innate	.22	−.49*	−.17	−.27	.32	−.20	−.34	.13	−.04	.25	.07	−.06	−.04
Can't learn how to learn	.16	.58*	−.13	−.27	−.09	−.14	−.14	.01	−.02	−.09	.12	.05	−.02
Success is unrelated to hard work	.45	−.35	.22	.00	.53*	.12	−.02	.04	.15	.52*	.04	.10	.15
Learn the first time	−.13	−.20	−.22	−.28	.17	.03	−.17	.06	.02	.18	.30	.13	.02
Learning is quick	.22	−.32	−.07	.12	.15	.01	−.15	−.15	−.09	.22	−.07	−.12	−.09
Concentrated effort is a waste of time	−.08	−.21	.18	−.37	.22	.17	−.01	.12	.24	.18	.07	.22	.24

	Duo problem-solving context																
Epistemological beliefs Scale	Inf(M)	E	Inference	PE	OS	VJ	VJ(M)	VJ(CId)	VJ(E)	VJ(PE)	VJ(OS)	Q(I)	Q(E)	Q(H)	Q(C)	SA	PD
Seek single answers	.08	−.01	−.21	−.18	.25	−.22	.08	−.15	−.02	.27	.30	−.38	−.09	.27	−.06	.00	−.12
Avoid integration	.01	−.16	.08	.29	.07	.05	.14	.40	−.31	.35	.25	.08	.09	.35	.16	−.19	.35
Avoid ambiguity	.30	.17	.07	−.20	.37	−.13	.27	.23	−.27	.34	.10	−.21	−.23	.34	.25	.12	−.19
Knowledge is certain	−.18	.10	−.16	−.02	−.11	−.00	−.16	−.16	.06	−.37	−.03	.02	−.10	−.37	−.12	−.26	−.18
Depend on authority	−.24	.16	.08	−.26	.14	.32	−.30	−.13	.32	.08	−.18	.21	.07	.08	.35	.35	−.10
Don't criticize authority	−.11	.32	−.11	−.40	.61**	−.09	−.28	−.39	−.13	−.09	.02	.12	−.20	−.09	.03	.35	−.24
Ability to learn is innate	−.11	−.14	−.19	−.01	.28	−.22	−.12	−.01	−.14	.33	.35	−.17	.01	.33	.21	−.02	−.04
Can't learn how to learn	.51*	.48*	−.05	−.24	−.10	−.08	.24	.07	−.29	.28	.32	−.11	−.36	.28	.11	.36	−.35

(continued)

Table 9.8 (continued)

	Solo problem-solving context																	
Epistemological beliefs scale	Inf(M)		CId	E		Inference		OS	VJ	VJ(M)	VJ(CId)	VJ(PE)		VJ(OS)	Q(E)		Q(H)	PD
Success is unrelated to hard work	−.12	−.50*	−.39		−.14	−.32	−.28	−.18	−.29	.03	.03	.18	−.27	−.03	.03	−.10	−.14	−.32
Learn the first time	−.10	.34	.23		.03	.11	.22	−.02	.28	−.03	.13	.34	.20	.09	.13	.46	.40	.01
Learning is quick	−.08	−.07	−.15		−.13	−.11	−.06	−.16	−.47*	.06	.23	.25	.01	.15	.23	.03	.12	−.19
Concentrated effort is a waste of time	.03	−.28	−.44		.02	−.14	.28	−.08	−.02	−.19	.46	.36	.38	−.10	.46	.26	.00	.163

* Significant at $p < .05$.
** Significant at $p < .01$.

9.6 Discussion

The chapter reports on the results of an exploratory study that was undertaken to investigate the relationship between epistemological beliefs and dispositions on students' thinking about an ill-defined issue in both solo and duo problem-solving contexts. We consider this research issue important for investigation, because despite the fact that there is some evidence in the literature connecting epistemological beliefs and dispositions with ill-defined problem solving (Sinatra et al., 2003; Kardash & Sinatra, 2003), it is still unclear whether epistemological beliefs and dispositions are stable constructs across different contexts, individual and social, and whether the sociocultural aspects of a context could trigger different aspects of one's epistemological beliefs and dispositions.

There are several interesting aspects to our findings regarding the relationship between epistemological beliefs and dispositions, and the role of these constructs on learners' thinking about an ill-defined issue in solo as well as duo problem-solving contexts.

First, our data showed that various epistemological belief scales correlated significantly with several dispositions. In particular, students who believed that learning is a slow, gradual, developmental process were also disposed toward truth-seeking, open-mindedness, analycity, systematicity, and maturity. Also, students who believed that the ability to learn is not fixed and can be changed were more likely to score high on the dispositions of truth-seeking, systematicity, and maturity. Students who believed that knowledge is tentative and evolving were positively disposed toward maturity and systematicity, and those who believed that knowledge is derived from reason were more disposed toward truth-seeking. Despite the fact that different studies have used different instruments for measuring dispositions and epistemological beliefs and thus direct comparison of findings is not possible, the results of this study corroborate some results reported by Kardash and Sinatra (2003) who found that open-minded thinking was positively correlated with the belief that learning and decision-making take time and effort.

A second aspect of our findings is that the elements of an individual's thinking about an ill-defined issue in a solo context differ with the elements of the individual's thinking when he or she thinks about the problem collaboratively with another person. Specifically, the results reported in this chapter show that when an individual thinks with others he or she is more likely to make more inferences than when he or she thinks alone, more value judgments even though they may not be supported by evidence, value judgments supported by evidence in the form of information given in reading materials, value judgments supported by evidence in the form of an emotion, and of course as one would expect in a collaborative setting, more evaluative questions, social acknowledgment statements, and clarification. These results indicate that problem solving within a social context is possible to trigger more cognitive and emotional activity for a learner than when he or she thinks alone.

A third aspect about our findings is that while dispositions were not associated with any of the elements of thinking in solo contexts, some dispositions correlated positively with elements of thinking in duo problem-solving contexts. Specifically, open-mindedness was correlated with emotion, analycity and self-confidence were correlated with value judgments not supported by evidence, and inquisitiveness was associated with personal experiences and personal data. Interestingly, epistemological beliefs were shown to be more stable traits than dispositions and were correlated with elements of thinking in both solo and duo problem-solving contexts.

Specifically, our data showed that the epistemological belief Ability to learn is innate was negatively correlated with the element of cultural identity, in the solo context only, suggesting that the less participants believed that the ability to learn is not fixed and can be changed the more likely they were to reason using statements that denoted their cultural identity. Also, in the solo context, the more students believed that they cannot learn how to learn the more they reasoned using statements that showed their cultural identity. Nonetheless, in the duo context, the more students believed that they cannot learn how to learn the more they reasoned using statements from the reading materials as well as emotional statements. Moreover, students, in the solo context, who believed that success was related to hard work they were more likely to use information from other sources and support their value judgments with information from other sources. In the duo context, the results showed that students who believed that success was related to hard work they were less likely to use emotional statements. Finally, in the duo context, students who believed that knowledge is derived from reason were more likely to use information from other sources, and those who believed that learning is a slow gradual process were less likely to back up their value judgments with statements that signified their cultural identity.

In essence, the results of the study showed that different aspects of epistemological beliefs and dispositions got activated when students thought alone and when they thought with others in a collaborative environment. Thus, it seems that collaboration triggered some aspects of epistemological beliefs and dispositions but not others. The same holds for individual thinking. One finding that we find intriguing is the role of emotions in group thinking but not individual thinking, and the relationship between emotions and some aspects of epistemological beliefs and dispositions in the duo problem-solving context only.

In conclusion, due to the fact that we employed a correlational research design we cannot make any causal assertions at this time, but based on the results of the study the reader can hypothesize about the nature of relationships between the constructs examined here and conduct experimental studies to further test these hypotheses. Despite this limitation, this chapter provides evidence which shows the similarities and differences between the constructs of dispositions and epistemological beliefs and their relationship with ill-defined problem solving in solo and duo contexts. We consider the latter as extremely important because it extends the study of epistemological beliefs beyond the individual level to a sociocultural level.

References

Bendixen, L.D., & Schraw G. (2001). *Why do epistemological beliefs affect ill-defined problem solving?* Paper presented at the meeting of the American Educational Research Association, Seattle, WA.

Bendixen, L. D., Dunkle, M. E., & Schraw, G. (1994). Epistemological beliefs and reflective judgment. *Psychological Reports*, 75, 1595–1600.

Beyer, B. K. (1995). *Critical thinking*. Phi Delta Kappa Educational Foundation.

Cacciopo, J. T., & Petty, R. E. (1982). The need for cognition. *Journal of Personality and Social Psychology*, 42(1), 116–131.

Chan, K. (2000). *Teacher education students' epistemological beliefs – a cultural perspective on learning and teaching*. Paper presented at the Meeting of the Association for Active Educational Researchers, Sidney, Australia.

Corbin, J., & Strauss, A. (1990). Grounded theory research: Procedures, canons, and evaluative criteria. *Qualitative Sociology*, 13, 3–21.

Elstein A. S., Schulman, L. S., & Sprafka, S. A. (1978). *Medical problem solving: An analysis of clinical reasoning*. Cambridge, MA: Harvard University Press.

Facione, N., Facione, P., & Sanchez, M. (1994). Critical thinking disposition as a measure of competent clinical judgment: The development of the California Critical Thinking Disposition Inventory. *Journal of Nursing Education*, 33, 345–350.

Facione, P., Sanchez, M., Facione, N., & Gainen, J. (1995). The disposition toward critical thinking. *The Journal of the General Education*, 44, 1–25.

Facione, P. A., & Facione, N. C. (1992). *The California Critical Thinking Dispositions Inventory (CCTDI) and the CCTDI Test Manual*. Millbrae, CA: California Academic Press.

Facione, P. A., Facione, N. C., & Giancarlo, C. A. (1996). *The California Critical Thinking Dispositions Inventory: Test manual*. Millbrae, CA: California Academic Press.

Greeno, J. (1991). A view of mathematical problem solving in school. In M. U. Smith (Ed.), *Toward a unified theory of problem solving* (pp. 69–98). Hillsdale, NJ: Lawrence Erlbaum.

Hare, W. (2003). The ideal of open-mindedness and its place in education. *Journal of Thought*, 38, 2, 3–10.

Oh, S., & Jonassen, D. H. (in press). Scaffolding online argumentation during problem solving. *Journal of Computer-Assisted Learning*.

Jonassen, D. H. (1996). Scaffolding diagnostic reasoning in case-based-learning environments. *Journal of Computing in Higher Education*, 8, 48–68.

Jonassen, D. H. (1997). Instructional design model for well-structured and ill-structured problem-solving learning outcomes. *Educational Technology: Research and Development*, 45(1), 65–95.

Jonassen, D. H. (2000). Toward a design theory of problem solving. *Educational Technology Research & Development*, 48, 63–85.

Kardash, C. M., & Sinatra, G. (2003, April). *Epistemological beliefs and dispositions: Are we measuring the same construct?* Poster paper presented at the Annual Meeting of the American Educational Research Association, Chicago, IL.

Langer, E. (1989). *Mindfulness*. Reading, MA: Addison Wesley.

Mayer, R. E. (1998). Cognitive, metacognitive, and motivational aspects of problem solving. *Instructional Science*, 26, 1, 49–63.

McBride, R. E., Xiang, P., & Wittenburg, D. (2002). Dispositions toward critical thinking: The preservice teachers' perspective. *Teachers and Teaching: Theory and Practice*, 8(1), 29–40.

Paul, R. (1993). *Critical thinking: What every person needs to survive in a rapidly changing world*. Santa Rosa, CA: Foundation for Critical Thinking.

Perkins, D. N., Hancock, C., Hobbs, R., Martin, F., & Simmons, R. (1986). Conditions of learning in novice programmers. *Journal of Educational Computing Research*, 2(1), 37–56.Perkins, D., Jay, E., & Tishman, S. (1993). Beyond abilities: A dispositional theory of thinking. *Merrill-Palmer Quarterly*, 38, 1–21.

Perkins, D., Tishman, S., Ritchhart, R., Donis, K., & Andrade, A. (2000). Intelligence in the wild: A dispositional view of intellectual traits. *Educational Psychology Review*, 12, 3, 269–293.

Perry, W. G. (1970). *Forms of intellectual and ethical development: A scheme*. New York: Holt (Rinehart & Winston).

Schommer, M. (1990). Effects of beliefs about the nature of knowledge on comprehension. *Journal of Educational Psychology*, 82, 498–504.

Schommer, M. (1994). Synthesizing epistemological belief research: Tentative understandings and provocative confusions. *Educational Psychology Review*, 6, 293–320.

Schommer, M. (1998). The influence of age and education on epistemological beliefs. *British Journal of Educational Psychology*, 68, 551–562.

Schommer, M., & Dunnell, P. A. (1997). Epistemological beliefs of gifted high school students. *Roeper Review, March*, 153–156.

Schraw, G., Dunkle, M. E., & Bendixen, L. D. (1995). Cognitive processes in well-defined and ill-defined problem solving. *Applied Cognitive Psychology*, 9, 523–538.

Sinatra, G. M., Southerland, S. A., McConaughy, F., & Demastes, J. W. (2003). Intentions and beliefs in students' understanding and acceptance of biological evolution. *Journal of Research in Science Teaching*, 40, 5, 510–528.

Strauss, A., & Corbin, J. (1990). *Basics of qualitative research: Grounded theory procedures and techniques*. London: Sage.

van Bruggen, J. M., & Kirschner, P. A. (2003). Designing external to support solving wicked problems. In J. Andriessen, M. Baker, & D. Suthers (Eds.), *Arguing to learn* (pp. 177–203). Dordrecht, The Netherlands: Kluwer.

Chapter 10
Family Environment, Epistemological Beliefs, Learning Strategies, and Academic Performance: A Path Analysis

Francisco Cano[1] and María Cardelle-Elawar[2]

Abstract This study of secondary school students examined the complex interrelationships between family environment variables (antecedents) as predictors of learning strategies and academic performance (consequences) and of epistemological beliefs (mediators) and tested the latter as mediators of the relationship between antecedents and consequences. The results of path analysis support a hypothesis generated from a model that is bound both by the theory and by previous research. Belief in Quick, effortless learning mediated the influence of family variables on Surface strategy, Metacognitive learning strategies and Academic performance. The better the family's intellectual climate, the higher the students' mature beliefs about learning, and consequently, her/his Deep and Metacognitive strategies and academic performance. The proposed model showed a better fit to the data when compared with the two alternative models. Finally, we discussed the need to build an integrated model of the likely origins of epistemological beliefs.

10.1 Introduction

Although research and theory on epistemological beliefs are receiving increasing attention and interest within educational psychology, there is no unified model for understanding and interpreting this. Instead, a rich variety of approaches exist, of which an excellent overview is provided in Hofer's works (Hofer & Pintrich, 1997; Hofer, 2001) in particular, and in special issues of two journals (Contemporary Educational Psychology, 2004, Vol 29, No. 2; and Educational Psychology Review, 2001, Vol 13, No. 4).

One of these approaches is Schommer's research programme that, as Hofer and Pintrich (1997) recognise, "is more quantitative than that of her predecessors and takes a more analytical view of the components of beliefs" (p. 106), and focuses particularly on how "learning is influenced by the epistemological beliefs that

[1] *University of Granada, Granada, Spain*

[2] *Arizona State University, Tempe, USA*

M. S. Khine (ed.), *Knowing, Knowledge and Beliefs: Epistemological Studies across Diverse Cultures.*

individuals hold" (Hofer, 2001, p. 367). Although Schommer's theory is based on Perry's studies (1968, 1970), it goes beyond these by deeming that epistemology exists in the form of a system of independent beliefs (defined as fundamental assumptions about the nature of learning and knowledge) which are part of the underlying metacognitive mechanism (Ryan, 1984; Schoenfeld, 1983; Schommer, 1990; Schommer et al., 1992; Hofer & Pintrich, 1997). These beliefs are measured by means of the Epistemological Questionnaire (EQ; Schommer, 1990) consisting of 63 items grouped into 12 subsets, which after factor analysis, yield four dimensions reflecting beliefs (stated from a naïve perspective) in Innate Ability, Quick Learning, Simple Knowledge, and Certain Knowledge (Schommer, 1990, 1993a).

Schommer's research programme has orientated part of our recent investigations on Spanish students' personal epistemology, for which we used the EQ. These investigations have focused on: (a) examining the relationships between epistemological beliefs and learning conceptions (Cano & Cardelle-Elawar, 2004); (b) analysing the change in epistemological beliefs through secondary school and the effects of epistemological beliefs on learning approaches, and of learning approaches on academic performance (Cano, 2005a); and (c) determining the interrelationships between study orchestrations, learning approaches, and epistemological beliefs in student teachers (Rodríguez & Cano, 2006).

Although research on Schommer's approach to the study of epistemological beliefs has been extensive and has enriched our knowledge about their constituent dimensions, two limitations have become apparent. First, while a substantial number of investigations have been conducted into the consequences of these dimensions (mainly into their linkages with learning and academic performance), only a few studies have explored their origins or antecedents (mainly regarding family environment). Second, while researchers have paid growing attention to the effects (both direct and indirect) of epistemological beliefs on learning strategies and academic performance (consequences), they have paid far less attention to building a model that articulates the relationship between the consequences and antecedents referred to, and the mediating role played by epistemological beliefs. The present research sets out to address these two limitations and to take the first steps towards generating an integrated model of the factors giving rise to and shaping epistemological beliefs.

10.2 The Origins of Epistemological Beliefs

In a special issue of *Educational Psychology Review,* Schraw (2001) declared that "little is known about the origin and development of individuals' epistemological beliefs" (p. 457). Three years later, in the introduction to the special issue of *Contemporary Educational Psychology* focused on the role of epistemological beliefs in learning and development in academic domains, Schraw and Sinatra (2004) called researchers' attention to the fact that "clearly, the field is moving towards understanding the roots of students' beliefs, not simply the nature of beliefs themselves" (p. 98).

Although research indicates some factors (e.g., age, gender, field of study, and level of education) (Cano, 2005a; Jehng et al., 1993; Schommer, 1993a, 1998) related to epistemological beliefs, very little is known nowadays about their origins, especially those related to family. Prior to Schommer's work, studies regarding epistemology outside the classroom were of a cross-cultural type and usually focused on exploring the possible conflict between the epistemology nurtured at home and that nurtured at school (Schommer, 1994). For example, the results of Pai's (1990) research suggested that while American school teachers seem to support a view of learning as personal (individual) involvement, students from shared function groups (e.g., Native Americans, Asian Americans) tend to conceive learning as more closely concerned with group achievement than individual achievement.

The results of Schommer's first two investigations (1990, 1993b) demonstrated that family can influence epistemological beliefs. Schommer (1990) carried out research, the results of which confirmed the conceptualisation of epistemological beliefs as a multidimensional construct made up of a set of independent dimensions, and found some of the predictors of epistemological beliefs. She asked junior college and university students (95% were either freshman or sophomores) to respond to some questions about home background and upbringing on a 5-point Likert scale (from 1 = seldom to 5 = always). These questions included various different aspects: Educational atmosphere and opportunity (e.g., parents' higher education and parents' occupational prestige score); encouragement towards independence (e.g., making decisions for oneself) and adherence to rules (e.g., enforcement of strict rules). These aspects were apparently assessed by means of individual items rather than scales.

Given the possibility of multi-colinearity within blocks of variables, each variable was used separately to predict each epistemological belief. Although the complete results of regression analyses were not included in the article, the author offered a summary Table (p. 501) showing those variables that were statistically significant predictors of epistemological beliefs. Two of the four dimensions detected by Schommer were related to three types of predictors of epistemological beliefs. Simple knowledge was predicted by some variables of educational atmosphere and opportunity (high level of parental education), encouragement towards independence (questioning parents' decisions) and adherence to rules or guidelines (strictness of rules in the family). Quick learning was predicted by some variables of educational atmosphere and opportunity (father's education), and of encouragement towards independence (discussions). Innate ability and Certain knowledge, the other two dimensions of epistemological beliefs, did not appear to show statistically significant relationships with the predictors referred to. In Schommer's words, "these results suggest that the more education parents have and the more they expect their children to take responsibilities in the home and in their own thinking, the more likely children will develop a sophisticated system of epistemological beliefs" (Schommer, 1990, p. 503).

The analysis of family as an important contributor to epistemological beliefs was continued in a later study. As the participants in the previous research were from different schools (junior college and university) and domains (social sciences and technological sciences), Schommer (1993b) used this fact to analyse whether the possible differences in epistemological beliefs between these groups could be explained by some of the students' characteristics. The results showed some differences in epistemological beliefs between junior college students and university students, which were attributed to different students' family characteristics.

The junior college students were more likely than the university students to believe that knowledge is simple and that learning is quick, as was shown in ANOVA analyses. The first difference disappeared when parental education and encouragement towards independence entered the equation of regression to predict beliefs in Simple knowledge. The second difference was eliminated when parental education, log of school year and gender entered the equation of regression to predict Quick learning. The results of this study, as of those mentioned previously, confirm that family (parents' education and upbringing) is an important variable that predisposes students to have certain epistemological beliefs. However, although this was acknowledged no subsequent studies have been undertaken until now, the only incidental exception being the recent work of Conley et al. (2004). They found that despite the fact that the change in elementary students' epistemological beliefs over time was not influenced by their families' socio-economic status (SES), low SES students did have more naive beliefs (e.g., knowledge is certain and resides in authority) than average SES students.

It has been shown in turn that SES and other variables of family background (e.g., parents' educational attainments) are related to students' academic achievement as predicted by some models of school learning (Adams et al., 2000; Cool & Keith, 1991; Marjoribanks, 2005a; Ryan & Adams, 1995). However, there are two aspects which merit further attention. First, while for the measurement of some variables, individual items are commonly used and this seems acceptable (e.g., for SES), for the measurement of some other variables (e.g., family environment) it would seem advisable to administer scales measuring well-designed constructs anchored in accepted theoretical models, instead of individual items. Second, a well-known model of the relationship between school learning and family is that of Moos (1991), which is based on a considerable body of research and emphasises that the influence of school and classroom learning environments might be altered by other contexts in the student's life (such as family environment), and that this has an impact on educational outcomes.

Family environment is a context of psychological functioning that can be defined according to multiple dimensions: Relationships, system maintenance and change, and personal growth or goal orientation (Moos & Moos, 1994), the latter being conceptualised as the underlying goals towards which a family is oriented (e.g., intellectual–cultural, moral–religious). Given the previous studies on the antecedents of epistemological beliefs, an interesting variable to select from this model would be intellectual climate. This refers to the family's degree of interest in social, political, cultural, and intellectual activities (Moos, 1991), its most widely accepted measure being the Intellectual–cultural subscale of the Family Environment Scale (FES) (Moos & Moos, 1994). The psychometric properties of this subscale (internal-consistency reliability, test–retest reliability, and discriminant validity) have been investigated and seem appropriate (Moos & Moos, 1994).

There is some research evidence for linking family environment and learning. The early research of McMillan and Hiltonsmith (1982) found that family intellectual orientation was related to adolescents' participation in leisure activities with adults, and to spending less time watching television and more time studying. Marjoribanks (1979, 2005a, 2005b), in line with Moos's model (1991), reported that family environment significantly affects the cognitive processes used by the student, which in turn determines academic attainment. The result of a recent study using high school students as participants (Cano, 2007) demonstrated that although family intellectual climate did not affect children's academic performance directly, the better the family's intellectual climate, the higher students' scores on Deep learning approach, the latter being a statistically significant positive predictor of academic performance. Moreover, those participants who orchestrated their study in conceptually dissonant or surface ways had the lowest scores on family intellectual climate and on metacognitive learning strategies.

10.3 The Consequences of Epistemological Beliefs

A healthy body of research has examined how epistemological beliefs are related to learning strategies and academic performance. In examining whether students' epistemological beliefs affected their interpretation of information and their metacomprehension of written text, Schommer et al. (1992) administered measures assessing mastery of the material and use of study strategies, the latter by means of the Test preparation and the Information processing scales of the Learning and Study Strategies Inventory (LASSI; Weinstein et al., 1987). Results suggested that the more university students believe in Simple knowledge the worse their comprehension, metacomprehension, and test performance. Moreover, the effect of the belief in Simple knowledge on test performance was both direct and indirect, via the test preparation strategies, as revealed by path analysis.

Kardash and Howell (2000) used an online measure of strategic processing rather than self-report measures, to determine whether readers' (undergraduate students') epistemological beliefs were related to the cognitive process and strategies they used to understand text. Results demonstrated that readers holding naïve beliefs about the speed of learning used fewer processing strategies (e.g., using background knowledge) overall than did their peers with more sophisticated beliefs about how quickly learning takes place.

Recently, Dahl et al. (2005) administered the EQ and the Motivated Strategies for Learning Questionnaire (MSLQ; Pintrich et al., 1993) to 81 undergraduate students. Correlational and full regression analyses (all predictors entered simultaneously) showed that participants' epistemological beliefs influenced their reported use of each of the five learning strategies measured (all these being relevant in facilitating text comprehension). Beliefs in Simple knowledge contributed negatively to the reported use of organisation and metacognitive self-regulation strategies, and also to the use of rehearsal strategies. The latter was an unexpected result, which the authors attributed, in part, to the low reliability of the rehearsal scale scores. Beliefs in Fixed ability contributed negatively to the reported use of elaboration, critical thinking and metacognitive self-regulation strategies. The other two factors of the EQ were not statistically significant predictors of any of the five learning strategies.

Analysis of the relationship between epistemological beliefs and academic performance in general, as opposed to test performance in text processing in particular, was performed by Schommer (1993a) using more than a thousand high school students as participants. Her results revealed that the more students believed in Simple knowledge, Certain knowledge, Quick learning, and Fixed ability, the lower their grade point average (GPA) was likely to be. In a follow-up longitudinal study, Schommer et al. (1997) selected at random 69 students who had been freshmen in 1992 and seniors in 1995. Here, only one factor, "quick learning", predicted students' achievement, that is, the greater their belief in Quick learning, the weaker their GPA. It may be that the small sample size did not allow the other factors to appear as significant predictors of GPA.

Other studies conducted in Spain supported Schommer's finding that epistemological beliefs were related to academic performance (Cano, 2005a; Cano & Cardelle-Elawar, 2004) and confirmed that the former can influence the latter indirectly, via learning approaches (Cano, 2005a). In this latter investigation, in which about 1,600 secondary school students took part, the EQ was used for the assessment of epistemological beliefs and the Learning Process Questionnaire (LPQ; Biggs, 1987) for the assessment of learning approaches. Path analysis revealed that (a) while belief in Certain knowledge did not account for student academic performance directly to any significant extent, beliefs in Quick learning and Simple Knowledge did (negative sign), (b) the three naïve epistemological beliefs mentioned predicted in a statistically significant way students' learning approaches: Surface and Deep (combined with Achieving approach) (naïve beliefs being positively related to Surface approach and negatively to Deep/Achieving approach). These learning approaches were, in their turn, negatively related to one another and predicted academic performance (Deep/Achieving approach positively and Surface approach negatively); and (c) belief in Quick learning had an impact on academic performance, not only directly but also indirectly through its influence on learning approaches.

In spite of these results, a review of the literature on the relationship between deep and surface approaches and academic outcomes indicates mixed results. While the results of some research show that deep approach contributes positively and Surface approach contributes negatively to learning outcomes (Entwistle & Ramsden, 1983; Sadler-Smith, 1996; Watkins, 2001; Zeegers, 2001), the results of other research indicated that Deep approach was a poor predictor of academic performance (Diseth & Martinsen, 2003; Groves, 2005; Jones & Jones, 1996; Provost & Bond, 1997; Watkins & Hattie, 1981).

10.4 Overview of the Present Study

The review undertaken of the studies on Schommer's multidimensional view of epistemological beliefs suggested many aspects that would seem to merit deeper examination.

First, there is a dearth of research on the roots (antecedents) of students' epistemological beliefs, mainly those linked to family variables, the measurement of which could be improved in some cases if scales anchored in well-known theoretical models and showing good psychometric properties (e.g., family intellectual climate) were used instead of individual items.

Second, although there is a growing body of research focused on the effects (consequences) of epistemological beliefs, three limitations have become apparent: (a) there are more studies on text processing in particular than on learning outcomes (e.g., academic performance) in general; (b) analysis of the indirect effects of epistemological beliefs on academic performance have focused on learning approaches (i.e., "processes" adopted during learning, which include motive and strategy components) as mediator variables, but not specifically on learning strategies (cognitive and metacognitive); and (c) those researchers who analysed learning strategies used a small number of participants and did not undertake an in-depth analysis of the relationships among learning strategies, and between the latter and academic performance.

Third, drawing on all the theoretical models described and all the research evidence collected, it seems there is sufficient basis to generate a model that articulates the relationship between the three types of variables referred to: antecedents, mediators, and consequences. A simplified version of this model enables us to assert that family variables (antecedents) influence learning strategies and academic achievement (consequences) both directly and indirectly through their effects on epistemological beliefs (mediator variables).

The theoretical and empirical evidence which emerged in the review of Schommer's multidimensional model of epistemological beliefs permits us to predict the following statistically significant relationships:

1. Parents' educational level and family's intellectual climate are two of the possible roots of epistemological beliefs about the speed and effort involved in learning, and consequently, the former will predict the latter.
2. While parents' educational level will predict academic performance and possibly some of the learning strategies, family's intellectual climate will be a strong predictor of learning strategies but not of academic performance.
3. Learning strategies will be related to one another and will influence academic performance: (a) we would expect the relationship between metacognitive learning strategies and deep strategy and between these and academic performance to be positive, but (b) negative between these two strategies and surface strategy, and between the latter and academic performance.
4. Epistemological beliefs about the speed and effort involved in learning will predict both learning strategies and academic performance, and will mediate the influence of family variables on these variables in general and metacognitive learning strategies in particular.

The ‘partially mediated model’ proposed in these hypotheses will be used as an organisational framework for the different analyses carried out in the present research. Mediation processes are common in educational psychology, and refer to an inferred causal sequence in which the effect of the independent variable (IV) affects the mediator (M), which in turn affects the dependent variable (DV), therefore explaining how IV affects DV. Baron & Kenny (1986) and Judd & Kenny (1981) have discussed three steps for establishing a mediation between an IV, an M, and a DV:

1. The first step is to show that the IV is correlated with the M. In a regression analysis a relationship between the IV and the M, treated as if it were a DV, must be established.
2. The second step is to show that the IV is correlated with the DV. In a regression analysis a relationship between the IV and the DV must be established.
3. The third step is to show that the M affects the DV. In a regression analysis a relationship must be established between M and DV by regressing the DV on both the IV and on the M.

The first two steps will be addressed in the present research using regression analyses. For the last step, although regression analyses will be shown (for informative purposes only), structural equation models (SEM) will be the core statistical technique used to analyse the data because, (a) the system of relationships among the variables being studied is large and complex, and (b) the partially mediational model referred to offers a basic theory of how the system of variable relationships ought to appear (in terms of SEM, “antecedents” are considered exogenous variables and “mediators” and “consequences” endogenous variables).

10.5 Method

10.5.1 Participants

The data set in the present study was collected as part of a research programme aimed at examining the epistemological beliefs, learning conceptions and learning approaches of Spanish secondary school students (see Cano & Cardelle-Elawar, 2004; Cano, 2005a, 2005b; Cano, 2007). Participants were 870 students (Grades 7–10) of whom 57.59% were girls and 42.41% boys, their ages ranging from 12 to 18 years ($M = 13.90$; $SD = 1.51$). Prior to the investigation, parents had given their consent for students to participate.

10.5.2 Instruments

Parents’ educational level was measured by asking students to indicate on a 6-point scale ranging from 0 = primary school or less to 6 = university degree, the highest level of education attained by each of their parents. Each participant received a score by taking the average of the two parents’ scores.

The *Family's Intellectual Climate* was assessed using the Intellectual–cultural subscale (Cronbach's $\alpha = .70$ for this study) of the Family Environment Scale (FES; Moos & Moos, 1994), and was composed of 9 true–false items (e.g., "my family really enjoys art, music and/or literature").

The *Deep strategy* and *Surface strategy* scales of the Learning Process Questionnaire (LPQ; Biggs, 1987) in its Spanish version (Barca, 1999). Each had six items (Cronbach's $\alpha = .59$ and .47, respectively for this study) which students were asked to rate on a Likert-type scale, from 1 (never or rarely true of me) to 5 (always or almost always true of me). While *Deep strategy* refers to a meaningful strategy for learning (searching for meaning, integrating formal knowledge with personal experience, and relating facts to conclusions), *Surface strategy* refers to a rehearsal strategy (concentrating on specific facts, memorising and reproducing them accurately).

The *Metacognitive learning strategies scale*, composed of nine items (Cronbach's $\alpha = .61$) was adapted from the Pintrich and De Groot (1990) MSLQ scales, and included planning, setting goals, monitoring comprehension, and regulating cognition (e.g., "When I'm reading I stop once in a while and go over what I have read"). Items were rated on the same 5-point Likert scale used for the Deep and Surface strategy scales.

The *Epistemological Questionnaire* (EQ), comprising 63 items, grouped in 12 subsets, for which participants indicated their response on 5-point Likert scale as previously mentioned. From previous exploratory and confirmatory analyses (Cano, 2005a) three factors emerged: Factor I: Belief in Quick, Effortless Learning (Quick, Effortless Learning); Factor II: Belief in Simple Knowledge (Simple Knowledge); Factor III: Belief in Certain Knowledge (Certain Knowledge). Inter-item reliabilities for scores on each factor, measured by means of Cronbach's α, were .64 for Factor I, .60 for Factor II, and .42 for Factor III. "The structure largely resembles that obtained by Schommer (1993a; 1998), the only major difference being that the scales about learning beliefs load together on the first factor; the second and third factors are similar to Schommer's" (Cano, 2005a, p. 210). The factor scores resulting from the EQ exploratory factor analysis were saved for later use in the different analyses. It is important to note that as EQ items are stated from the naïve perspective, the higher students' scores on these factors, the more naïve will be their epistemological beliefs.

10.5.3 Procedure

Participants were informed about the study, received specific instructions to complete the instruments during whole-class sessions, and were asked to provide demographic information, such as name, gender, and age. They were assured of the confidentiality of their responses and that their answers would not affect their grades. At the end of the academic year, students' grades for all subjects were noted, along with the mean of these values or average mark, which was used as a measure of academic performance.

10.5.4 Statistical Analyses

Data obtained were submitted to descriptive and standard regression analyses by using the 1D and 1R programmes of the BMDP statistical package (Dixon, 1985). Structural equations (path analysis) were used to analyse the recursive model (i.e., all the arrows flowing one way, with no feedback looping) proposed, which was tested using LISREL 8 (Jöreskog & Sorbom, 1996). Regarding path analysis, it is appropriate to specify that it is an observational tool rather than a manipulative or experimental technique for modelling a theoretically hypothesised relationship among variables (Keitz, 1988). This technique, which is a subset of SEM, allows the simultaneous assessment of a large number of relationships (both directly from one variable to another and via other variables positioned between the two) and can determine how closely they conform to a theory-predicted pattern. Pathways in path models, however, represent the hypotheses of researchers, and can never be statistically tested for directionality (Everitt & Dunn, 1991).

10.6 Results

10.6.1 Regression Analyses (I): Family Variables as Predictors of Epistemological Beliefs (IV → M)

In Table 10.1, the results of three standard regression analyses can be seen. In all the analyses the same IVs, relating to parents' educational level and family's intellectual climate, are used, but the DVs. are different: Quick, Effortless Learning for the first analysis; Simple Knowledge for the second, and Certain Knowledge for the third.

Only the results of the first analysis indicated statistically significant contributions of parents' educational level and family's intellectual climate to the prediction of Quick, Effortless Learning. The higher the students' scores in these family variables, the lower their naïve beliefs that learning occurs quickly and without hard work.

10.6.2 Regression Analyses (II): Family Variables as Predictors of Learning Strategies and Academic Performance (IV → DV)

In Table 10.2, the results of four standard regression analyses can be seen. In all the analyses the same IVs, relating to parents' educational level and family's intellectual climate, are used, but the DVs are different: Deep Strategy for the first analysis, Surface Strategy for the second, Metacognitive learning strategies for the third, and Academic Performance for the fourth.

Table 10.1 Summary of the three standard regression analyses for family variables (IV) predicting epistemological beliefs (DV)

Variables	R^2	Adj	F	p	b	β	t	p	Sr^2
1. Quick L$^{(DV)}$	.043	.409	19.53	<.001					
Parents' EL$^{(IV)}$					−.08	−.12	−3.33	<.001	.0073
Family's IC$^{(IV)}$					−.07	−.14	−4.11	<.001	.0111
2. Simple K$^{(DV)}$	.004	.001	1.84	.158					
Parents' EL$^{(IV)}$					−.03	−.06	−1.51	.120	.0028
Family's IC$^{(IV)}$					−.01	−.02	−.61	.540	.0004
3. Certain K$^{(DV)}$	.000	−.002	.01	.989					
Parents' EL$^{(IV)}$					.00	.01	.15	.880	.0000
Family's IC$^{(IV)}$					.00	.00	−.05	.960	.0000

Note. IV = Independent variable. DV = Dependent variable. R = Multiple correlation. R^2 = Squared multiple correlation. Adj = Adjusted R^2. b = Unstandardised regressioncoefficient β = Standardised regression coefficient. Sr^2 = Squared semi-partial correlation. Quick L. = Quick, Effortless learning. Simple K. = Simple Knowledge. Certain K. = Certain Knowledge.

Table 10.2 Summary of the four standard regression analyses for family variables (IV) predicting learning strategies and academic performance (DV)

Variables	R^2	Adj	F	p	b	β	t	p	Sr^2
1. Deep Str$^{(DV)}$	.068	.058	28.05	<.001					
Parents' EL$^{(IV)}$					−.00	−.02	−.58	.560	.0004
Family's IC$^{(IV)}$					.08	.25	7.32	<.001	.0581
2. Surface Str$^{(DV)}$	.055	.053	25.65	<.001					
Parents' EL$^{(IV)}$					−.07	−.16	−4.71	<.001	.0241
Family's IC$^{(IV)}$					−.04	−.13	−3.82	<.001	.0158
3. Metacogn$^{(DV)}$	.077	.075	36.60	<.001					
Parents' EL$^{(IV)}$					.25	.09	2.64	.010	.0074
Family's IC$^{(IV)}$					.49	.24	7.09	<.001	.0527
4. Aca Perf$^{(DV)}$	.010	.099	48.75	<.001					
Parents' EL$^{(IV)}$					.20	.29	8.55	<.001	.0835
Family's IC$^{(IV)}$					.04	.08	2.28	.020	.0059

Note. IV = Independent variable. DV = Dependent variable. R = Multiple correlation. R^2 = Squared multiple correlation. Adj = Adjusted R^2. b = Unstandardised regression coefficient. β = Standardised regression coefficient. Sr^2 = Squared semi-partial correlation.

In the first analysis only family's intellectual climate contributed with statistically significant beta weights to the prediction of the scores on Deep Strategy. In the other three analyses, parents' educational level and family's intellectual climate contributed significantly to the prediction of Surface Strategy, Metacognitive learning Strategy and Academic Performance. However, the unique contribution of family's intellectual climate in predicting Academic Performance, and of parents' educational level in predicting Metacognitive learning strategy were low.

10.6.3 Regression Analyses (III): Family Variables and Epistemological Beliefs as Predictors of Learning Strategies and Academic Performance (IV, M → DV)

In Table 10.3, the results of four standard regression analyses can be seen. In all the analyses the same M variables, relating to epistemological beliefs (Quick, Effortless Learning; Simple Knowledge; and Certain Knowledge) are used as IVs whilst controlling for the previous IVs relating to family variables (parents' educational level and family's intellectual climate). The DVs are, however, different: Deep Strategy for the first analysis, Surface Strategy for the second, Metacognitive learning strategies for the third, and Academic Performance for the fourth.

The variable Quick, Effortless Learning was the only one to obtain strong, statistically significant contributions in all four regression analyses, predicting all the learning strategies as well as Academic performance. The fact that Quick, Effortless Learning is the only epistemological belief variable predicted by family variables and that this in turn predicts learning approaches and Academic performance proves it to be the only statistically significant mediator variable in the proposed model.

Table 10.3 Summary of the 12 standard regression analyses for epistemological beliefs (IV) predicting learning strategies and academic performance (DV)

Variables	R^2	Adj	F	p	b	β	t	p	Sr^2
1. Deep Str$^{(DV)}$									
Quick L$^{(IV)}$	.085	.081	26.80	<.001	−.09	−.16	−4.78	<.001	.0242
Simple K$^{(IV)}$	.073	.070	22.80	<.001	.07	.11	3.41	<.001	.0124
Certain K$^{(IV)}$	.061	.058	18.82	<.001	−.01	−.02	−.65	.52	.0005
2. Surface Str$^{(DV)}$									
Quick L$^{(IV)}$	.092	.089	29.32	<.001	.12	.19	5.89	<.001	.0364
Simple K$^{(IV)}$	.087	.084	27.56	<.001	.11	.18	5.45	<.001	.0313
Certain K$^{(IV)}$	.056	.052	17.12	<.001	−.00	−.01	−.33	.74	.0001
3. Metacogn$^{(DV)}$									
Quick L$^{(IV)}$	.123	.120	4.59	<.001	−.86	−.22	−6.70	<.001	.0454
Simple K$^{(IV)}$	.082	.079	25.86	<.001	.27	.07	2.03	.04	.0044
Certain K$^{(IV)}$	.085	.082	27.06	<.001	.37	.09	2.73	.01	.0079
4. Aca Perf$^{(DV)}$									
Quick L$^{(IV)}$	.170	.167	59.37	<.001	−.27	−.27	−8.52	<.001	.0696
Simple K$^{(IV)}$	.101	.098	32.47	<.001	−.00	−.01	−.17	.87	.0000
Certain K$^{(IV)}$	.101	.098	32.57	<.001	.01	.02	.54	.59	.0003

Note. IV = Independent variable whilst controlling for Parents' educational level and Family's intellectual climate. DV = Dependent variable. R = Multiple correlation. R^2 = Squared multiple correlation. Adj = Adjusted R^2. b = Unstandardised regression coefficient. β = Standardised regression coefficient. Sr^2 = Squared semi-partial correlation. Quick L. = Quick, Effortless learning. Simple K. = Simple Knowledge. Certain K. = Certain Knowledge.

10.6.4 Mediational Analyses

The proposed partially mediated model provided an adequate fit to the data: $\chi^2_{(3)}$ = 3.99, p = .26; GFI = 1.00; SRMR = .0009; NNFI = .99; and CFI = 1.00, and explained a modest portion of the variance in Quick, Effortless learning (4%), Deep strategy (8%), and Surface Strategy (10%), and a notable portion of the variance in Metacognitive learning strategies (28%) and Academic Performance (27%).

Standardised parameter estimates are presented in Fig. 10.1.

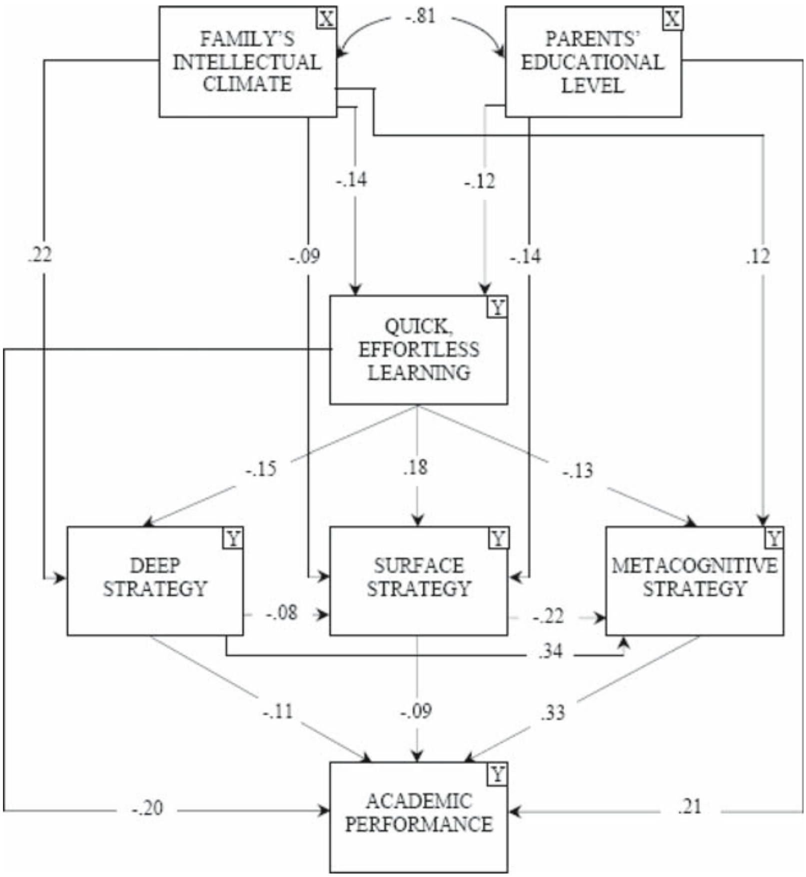


Fig. 10.1 Path analysis of the partially mediated model: Direct effects of quick, effortless learning as a mediator variable between family's variables and learning outcomes

As shown, several statistically significant (standardised beta weights) relationships emerged; the direct ones will be described first, followed by the indirect ones.

a. Parents' educational level and family's intellectual climate were negative predictors of the epistemological belief in Quick and Effortless learning.

b. Family's intellectual climate predicted Deep strategy and Metacognitive learning strategy positively, and Surface strategy, but not Academic Performance negatively. Parents' educational level predicted Surface strategy negatively and Academic Performance positively.
c. Deep strategy was linked positively to Metacognitive learning strategies and negatively to Surface strategy. Academic performance was predicted negatively by both Surface and Deep strategy (unexpectedly), and positively by Metacognitive learning strategies.
d. Belief in Quick, Effortless learning was a negative predictor of Deep strategy, Metacognitive learning strategies, and Academic Performance, and a positive predictor of Surface strategy. This epistemological belief had indirect as well as direct effects on diverse variables, as was the case with some of the other variables (see Table 10.4).

Table 10.4 Standardised indirect and total effects of exogenous variables on endogenous variables (X → Y) and of endogenous variables on endogenous variables (Y → Y) from path analysis

	Exogenous variables (X)				Endogenous variables (Y)							
Endogenous	PEL		FIC		QL		DS		SS		MS	
Variables (Y)	I	T	I	T	I	T	I	T	I	T	I	T
Quick E. Learning		−.12		−.14								
Deep Strategy	.02	.02	.02	.24		−.15						
Surface Strategy	−.02	−.17	−.04	−.04	.01	.19		−.08				
Metacognitive Strategy	.06	.06	.13	.25	−.10	−.22	.02	.36		−.22		
Academic Performance	.05	.27	.09	.09	−.07	−.27	.13	.01	−.07	−.17		.33

Note: PEL = Parents' educational level. FIC = Family intellectual climate. QL = Quick, Effortless learning. DS = Deep strategy. SS = Surface strategy. MS = Metacognitive strategy. I = Standardised indirect effects. T = Standardised total effects.

The belief in Quick, Effortless learning mediated the influence of family variables on Surface strategy, Metacognitive learning strategies and Academic performance.

While parents' educational level had few indirect effects on learning strategies and Academic performance, the indirect effects of family's intellectual climate were greater, especially those concerning Metacognitive learning strategies.

Finally, it is important to note that Deep strategy had an indirect effect on Academic performance, via Metacognitive learning strategies in particular ($.34 \times .33 = .11$).

As other models may fit the same data, two alternative models were proposed, a non-mediated and a mediated model. The non-mediated model (no paths between Quick, Effortless learning and the other endogenous variables) provided a modest fit to the data: $\chi^2_{(7)} = 112.119$, $p < .00$; GFI =.97; SRMR = .079; NNFI = .62; and CFI = .87. Likewise, the mediated model (no paths between the exogenous variables and the endogenous except for Quick, EFfortless learning) obtained a modest fit to the data: $\chi^2_{(8)} = 143.60$, $p < .00$; GFI = .96; SRMR = .091; NNFI = .57; and CFI = .84.

Our proposed partially mediated model showed the best results when compared with both the non-mediated model ($\chi^2_{\text{difference}(4)} = 107.12$; $p < .001$); and the mediated model ($\chi^2_{\text{difference}(5)} = 139.61$; $p < .001$).

10.7 Discussion

In the present research, a review of some antecedents (family characteristics) and consequences (learning strategies and academic performance) of epistemological beliefs was undertaken, and a model that involved associations (both direct and indirect) among these variables was proposed and tested.

The model was bound by the theory and by previous research and, because of the apparently complex influences among antecedents, consequences, and epistemological beliefs (mediators), the results of preliminary regression analyses were reported, in order to facilitate comprehension of these influences in the methodological framework of the steps for establishing mediation (Baron & Kenny, 1986; Judd & Kenny (1981). The results of the first group of regression analyses reveal that antecedent variables are significant predictors of only one of the possible mediator variables, Belief in Quick, Effortless learning (first step), while the results of the second group of regression analyses show that antecedent variables are associated with some of the variables relating to the consequences of epistemological beliefs (second step). Taken together, these results show, that Belief in Quick, Effortless learning is the variable that meets the first two requisites (steps 1 and 2) and which accounts for the relationship between antecedents and consequences (i.e., its function as a mediator variable).

Given the numerous relationships among variables in the model, path analysis is preferred to traditional regression analyses for the final step to determine mediation because it is more structured and explicit than the latter. Path analysis is an extension of the regression model, which is theory-driven and allows us to decompose correlations in the model into direct and indirect effects, and to test mediation. The results were highly consistent with the hypotheses generated by the epistemological beliefs framework and will be discussed following the order implicit in the proposed model.

First, the model specifies that parents' educational level and family's intellectual climate are two possible roots of epistemological beliefs about the speed and effort involved in learning, which in their turn influence students' learning strategies and academic performance and mediate the effects of family variables.

The results of path analysis suggest that some family characteristics can predict children's epistemological beliefs. The lower the educational level of the parents, the more likely their children will develop naïve beliefs about Quick, Effortless learning, a result which is in agreement with those of Schommer (1990, 1993a). It is important to note that these beliefs depend not only on parents' educational attainments, but also on how these attainments are converted into an interest in social, cultural, political, and intellectual activities (family intellectual–cultural climate). The better the family's intellectual climate, the more sophisticated the child's beliefs about learning. Although this finding is broadly consistent with those of Schommer (1990, 1993b) as regards family upbringing, it goes somewhat too far. A reliable and valid scale reflecting one dimension of family environment is being used instead of separate items, and one model (Moos, 1991) is taken as the theoretical framework.

Family characteristics are also directly related to the cognitive and metacognitive learning strategies that students engage in their school learning, and to the academic achievement they attain. However, it is necessary to differentiate between family's intellectual climate, which is linked to all the learning strategies but not to Academic Performance, and parents' educational level, which is associated only with Surface strategy but predicts Academic Performance. The present pattern of results is in line with those of the literature (Adams et al., 2000; Cool & Keith, 1991; Ryan & Adams, 1995; Cano, 2007).

In the complex relationships between variables demonstrated by the model, more important perhaps than direct effects are the indirect effects. The latter showed clearly that a belief in Quick, Effortless learning mediates the influence of family characteristics on children's learning strategies and Academic Performance. Parents' educational level and family's intellectual climate show roughly similar indirect effects, except for those on Metacognitive learning strategies, which are greater. The belief referred to is also indirectly related to Surface Strategy and Academic Performance, but most strongly to Metacognitive learning strategies: Students whose families encourage discussion and an interest in culture and that are intellectually inclined appear to predispose their children to have mature beliefs about learning and indirectly predispose them to deploy strategies aimed at regulating and controlling their learning (which in turn is the variable with the highest positive impact on Academic Performance). Previous research shows the mediator role of epistemological beliefs on comprehension test performance (Schommer et al., 1992; Kardash & Howell, 2000) and the findings of our research extend this to Academic Performance and to a wider range of strategies. Moreover, it confirms the expected links between metacognition and students' fundamental assumptions about the nature of learning (Schommer, 1990; Schommer et al, 1992; Hofer & Pintrich, 1997).

With regard to the relationships between Deep and Surface strategies and Academic Performance, the results were somewhat mixed, as were those encountered in the literature review. Surface and Deep learning strategies were negatively associated with one another, but both were negatively linked to Academic Performance. Although this result differs from those of a previous study (Cano, 2005a), in which it was detected that a Deep/Achieving approach positively predicted academic performance, two possible reasons besides the mixed results of the literature review might explain this disagreement. First, the construct labelled "approach" is construed as fusing strategy and motive, the latter not being included in the present study. Second, while four scales defined the Deep/Achieving approach, as determined by the factor analyses scores of the LPQ scales, only one scale was used in the present research.

Although the results of path analysis show a disconcerting negative relationship between Deep strategy and Academic Performance, they also reveal a slightly more reassuring strong (indirect, but positive) effect of Deep strategy on Metacognitive learning strategies. While the former might suggest that deploying a meaningful strategy for learning is not rewarded directly by the teaching–learning system, the latter might indicate that it is not enough merely to facilitate students' elaboration of the information and integration of it with prior knowledge and experience; it is also necessary to monitor comprehension and regulate cognition.

The positive link between Metacognitive learning strategies and Deep strategy does not, however, detract from our concern about the negative relationship referred to. Neither does it prevent us raising the question of what is happening in our teaching–learning system (and also in other systems) that leads us to detect an undesirable association between the learning strategy of searching for meaning and academic achievement. A worrying finding in our previous research was that, as in other education systems (Watkins & Hattie, 1985; Biggs, 1987; Biggs & Moore, 1993), students' learning approach scores declined during their secondary school years. The situation in other countries appears to be similar. In Norway, Diseth and Martinsen (2003) found that the deep approach unexpectedly failed to predict undergraduate Psychology students' achievement; and in Australia, Zeegers (2001) detected that students "are not encouraged to engage in favourable approaches to learning, that is deep learning, as a result of the tertiary experience" (p. 130).

Undoubtedly, further research is required to answer the question posed and to draft possible solutions. The question may appear complex; the solutions are no less so, because there is some evidence that even well thought out teaching innovations sometimes produce bizarre effects. Groves (2005) found that first-year medical students who received a problem-based learning (PBL) curriculum shifted from deep learning towards a more surface approach over the period of study. The author argues that learning approaches are context-dependent and suggests that some factors (e.g., assessment, work load) are possibly greater determinants of learning approaches than the type of curriculum. Vermetten et al. (2002) call researchers' attention to the fact that some failures of interventions to encourage the deployment of deep and self-regulated learning approaches (e.g., powerful learning environments) could be explained by the variations in students' perceptions and their tendency to use instructional innovations in different ways, to suit their own particular way of learning.

As the way students learn is possibly influenced by features of the learning context, such as the nature of the assessment requirements, course contents, or the teacher's conceptions of teaching (Entwistle & Ramsden, 1983; Entwistle et al., 2001) it seems important to continue researching and to insist on quality assurance, but taking into account how students are perceiving and interpreting the innovative teaching–learning environments we are offering them, and consequently, how these innovations are impacting on their learning experience (Biggs, 2001). This is certainly important when we consider that features of the learning context are also possibly influencing students' beliefs about knowledge, knowing, and learning, as suggested by Hofer's (2001) model of the relationships among epistemological theories and the classroom.

Two general limitations of the current investigation should be kept in mind. First, one of the assumptions of path analysis is that the variables used should be measured without error (Keitz, 1988; Stage et al., 2004). One method of dealing with this potential problem is to use factor scores whenever possible. Although they were used for the measurement of epistemological beliefs, the fact that the reliability of the measurement of the EQ factors was modest (mainly for Certain Knowledge) raises some concerns about the instrument, which might explain, in part, why only beliefs about learning were related to family variables. As some researchers have pointed out, the phrasing of some items is confusing because it includes first-, second-, and third-person format (Hofer & Pintrich, 1997), and the meaning of some items may also be difficult in some cases (e.g., justification for knowing) (Hofer, 2000). These difficulties might be exacerbated in the case of young secondary students, suggesting that it might be advisable to carry out further investigation into how to improve the instrument or even "to venture beyond Likert-type scales for more breadth of assessment…of…such beliefs" (Hofer, 2000, p. 399), but always taking into account the critical role of theory for its development (Duell & Schommer-Aikins, 2001). With this in mind, some of the contributors to this volume (Schraw; Buelh; Stace et al.) have highlighted several difficulties in assessing epistemological beliefs and proposed new perspectives for improving the process. Most researchers have probably learnt from experience that the future of a given topic depends strongly on the existence of two related aspects: Well-defined theoretical models and reliable, valid, and usable instruments. This seems to be the best way to test theories and their various implications. Second, it is implicitly assumed that epistemological beliefs have their roots in the family environment. Obviously family variables do not include all the possible reasons for epistemological beliefs, and the low percentage of variance explained by family variables clearly points to such a conclusion. However, as one of the requirements of path analysis is the existence of a true, or non-spurious relationship between the variables, the important common causes of both the exogenous and the endogenous variables should be included (Keitz, 1988). There is thus a pressing need to explore other sources of epistemological beliefs (and of learning strategies), which could plausibly be present in the school environment (e.g., teaching practices, teachers' epistemological theories) (Buehl & Alexander, 2001; Hofer, 2001). As these sources are probably linked, an in-depth analysis of their interrelationships would help to generate a working model of when and how these beliefs take root, and to ensure and enhance the quality of school learning and lifelong learning.

In summary, the present research shows that, (a) beliefs about the speed and effort involved in learning have some roots in family environment, (b) these beliefs mediate the influence of family variables on learning strategies (cognitive and metacognitive) and Academic Performance, and (c) it seems necessary to build an integrated model of the possible origins of fundamental assumptions about the nature of learning and knowledge.

References

Adams, G. R., Ryan, B. A., Keating, L., & Midgett, J. (2000). Family climate, parent-child interactions about school issues, children's characteristics and school achievement: A test of a family-school relationship model. *Contemporary Educational Psychology*, 27, 132–143.

Barca, A. (1999). *Manual del cuestionario de procesos y estrategias de aprendizaje para el alumnado de educación secundaria (CEPA)* (Manual for the learning process and strategies for secondary-level students). A Coruña: Publicaciones de la Revista Galego-Portuguesa de Psicoloxía e Educación.

Baron, R. M. & Kenny, D. A. (1986). The moderator-mediator variable distinction in social psychology research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology*, 51(6), 1173–1182.

Biggs, J. (1987). *Learning process questionnaire*. Melbourne: Australian Council for Educational Research.

Biggs, J. B. (2001). Enhancing learning: A matter of style or approach? In R. J. Sternberg & L. F. Zhang (Eds.), *Perspectives on thinking, learning, and cognitive styles* (pp. 73–102). Mahwah, NJ: Lawrence Erlbaum.

Biggs, J. B., & Moore, P. (1993). *The process of learning* (3rd edition). New York: Prentice-Hall.

Buehl, M. M., & Alexander, P. A. (2001). Beliefs about academic knowledge. *Educational Psychology Review*, 13(4), 385–418.

Cano, F. (2005a). Epistemological beliefs and approaches to learning: Their change through secondary school and their influence on academic performance. *British Journal of Educational Psychology*, 75, 203–221.

Cano, F. (2005b). Consonance and dissonance in students' learning experience. *Learning and Instruction*, 15, 201–223.

Cano, F. (2007). Approaches to learning and study orchestrations in high school students. *European Journal of Educational Psychology*, 22, 131–151.

Cano, F., & Cardelle-Elawar, M. (2004). An integrated analysis of secondary students' conceptions and beliefs about learning. *European Journal of Educational Psychology*, 19(2), 167–187.

Conley, A. M., Pintrich, P. R., Vekiri, I., & Harrison, D. (2004). Changes in epistemological beliefs in elementary science students. *Contemporary Educational Psychology*, 29, 186–204.

Cool, V. A., & Keith, T. Z. (1991). Testing a model of school learning: Direct and indirect effects on academic achievement. *Contemporary Educational Psychology*, 16, 28–44.

Dahl, T. I., Bals, M., & Turi, A. L. (2005). Are students' beliefs about knowledge and learning associated with their reported use of learning strategies? *British Journal of Educational Psychology*, 75, 257–273.

Diseth, A., & Martinsen, O. (2003). Approaches to learning, cognitive style, and motives as predictors of academic achievement. *Educational Psychology*, 23(2), 195–207.

Dixon, W. J. (Ed.). (1985). *BMDP statistical software*. Berkeley, CA: University of California.

Duell, O. K., & Schommer-Aikins, M. (2001). Measures of people's beliefs about knowledge and learning. *Educational Psychology Review*, 13(4), 419–449.

Entwistle, N. J., & Ramsden, P. (1983). *Understanding student learning*. London: Croom Helm.

Entwistle, N., McCune, V., & Walker, P. (2001). Conceptions, styles and approaches within higher education: Analytic abstractions and everyday experience. In R. J. Sternberg & L. F. Zhang (Eds.), *Perspectives on thinking, learning, and cognitive styles* (pp. 103–136). Mahwah, NJ: Lawrence Erlbaum.

Everitt, B. S., & Dunn, G. (1991). *Applied multivariate data analysis*. London: Edward Arnold.

Groves, M. (2005). Problem-based learning approach: Is there a relationship? *Advances in Health Science Education*, 10(4), 315–326.

Hofer, B. K. (2000). Dimensionality and disciplinary differences in personal epistemology. *Contemporary Educational Psychology*, 25, 378–405.

Hofer, B. K. (2001). Personal epistemology research: Implications for learning and instruction. *Educational Psychology Review*, 13(4), 353–383.

Hofer, B. K., & Pintrich, P. R. (1997). The development of epistemological theories: Beliefs about knowledge and knowing and their relation to learning. *Review of Educational Research*, 67(1), 88–140.

Jehng, J. J., Johnson, S. D., & Anderson, R. C. (1993). Schooling and students' epistemological beliefs about learning. *Contemporary Educational Psychology*, 18(1), 23–35.

Jones, A., & Jones, D. (1996). Student orientation to independent learning. *Higher Education Research and Development*, 15(2), 83–96.

Jöreskog, K. G., & Sorbom, D. (1996). *LISREL 8: User's reference guide*. Chicago, IL: SSI.

Judd, C. M., & Kenny, D. A. (1981). Process analysis: Estimating mediation in treatment evaluations. *Evaluation Review*, 5, 602–619.

Kardash, C. A. M., & Howell, K. L. (2000). Effect of epistemological beliefs on topics-specific beliefs on undergraduates' cognitive and strategic processing of dual-positional text. *Journal of Educational Psychology*, 92(3), 524–535.

Keitz, T. Z. (1988). Path analysis: An introduction for school psychologists. *School, Psychology Review*, 17(2), 343–362.

Kelloway, E. K. (1998). *Using LISREL for structural equation modelling. A researcher's guide*. London: Sage.

Marjoribanks, K. (1979). *Families and their learning environments: An empirical analysis*. London: Routledge & Kegan Paul.

Marjoribanks, K. (2005a). Family environments and children's outcomes. *Educational Psychology*, 25(6), 647–657.

Marjoribanks, K. (2005b). Correlations among family environment, academic achievement, and academic attainment in a large sample of young Australian adults. *Psychological Reports*, 97(2), 639–644.

McMillan, D., & Hiltonsmith, R. (1982). Adolescent at home: An exploratory study of the relationship between perception of family social climate, general well-being, and actual behavior in the home setting. *Journal of Youth and Adolescence*, 11, 301–315.

Moos, R. H. (1991). Connections between school, work, and family settings. In B. J. Fraser (Eds.), *Educational environments: Evaluation, antecedents, and consequences* (pp. 29–53). New York: Pergamon.

Moos, R., & Moos, B. (1994). *Family environment scale manual: Development, applications, and research*. Palo Alto, CA: Consulting Psychologist Press.

Pai, Y. (1990). *Cultural foundation of education*. Columbus: Merrill.

Perry, W. G. (1968). *Patterns of development in thought and values of students in a liberal arts college: A validation of a scheme*. Cambridge, MA: Bureau of Study Counsel, Harvard University.

Perry, W. G. (1970). *Forms of intellectual and ethical development in the college years: A scheme*. New York: Holt (Rinehart & Winston).

Pintrich, P. R., & De Groot, E. V. (1990). Motivational and self-regulated learning components of classroom academic performance. *Journal of Educational Psychology*, 82(1), 33–40.

Pintrich, P. R., Smith, D., García, T., & McKeachie, W. (1993). Predictive validity and reliability of the Motivated Strategies for Learning Questionnaire (MSLQ). *Educational and Psychological Measurement*, 53, 801–813.

Provost, S. C., & Bond, N. W. (1997). Approaches to studying and academic performance in a traditional psychology course. *Higher Education Research and Development*, 16(3), 309–320.

Rodríguez, L., & Cano, F. (2006). The epistemological beliefs, learning approaches and study orchestrations of university students. *Studies in Higher Education*, 31, 617–636.

Ryan, M. P. (1984). Monitoring text comprehension: Individual differences in epistemological standards. *Journal of Educational Psychology*, 76, 248–258.

Ryan, B. A. & Adams, G. R. (1995). The family-school relationships model. In B. A. Ryan, G. R. Adams, T. P. Gullotta, R. P. Weissberg, & R. L. Hampton (Eds.), *The family-school connection: Theory, research, and practice* (pp. 3–28). Newbury Park, CA: Sage.

Sadler-Smith, E. (1996). Approaches to studying: Age, gender and academic performance. *Educational Studies*, 22(3), 367–379.

Schoenfeld, A. (1983). Beyond the purely cognitive: Belief systems, social cognitions, and metacognitions as driving forces in intellectual performance. *Cognitive Science*, 7(4), 329–363.

Schommer, M. (1990). Effects of beliefs about the nature of knowledge on comprehension. *Journal of Educational Psychology*, 82, 498–504.

Schommer, M. (1993a). Epistemological development and academic performance among secondary students. *Journal of Educational Psychology*, 85(3), 406–411.

Schommer, M. (1993b). Comparisons of beliefs about the nature of knowledge and learning among post-secondary students. *Research in Higher Education*, 34(3), 355–370.

Schommer, M. (1994). An emerging conceptualization of epistemological beliefs and their role in learning. In R. Garner & P. A. Alexander (Eds.), *Beliefs about text and instruction with text* (pp. 25–40). Hillsdale, NJ: Lawrence Erlbaum.

Schommer, M. (1998). The influence of age and education on epistemological beliefs. *British Journal of Educational Psychology*, 68, 551–562.

Schommer, M., Calvert, C., Gariglietti, G., & Bajaj, A. (1997). The development of epistemological beliefs among secondary students: A longitudinal study. *Journal of Educational Psychology*, 89(1), 37–40.

Schommer, M., Crouse, A., & Rhodes, N. (1992). Epistemological beliefs and mathematical text comprehension: Believing it is simple does not make it so. *Journal of Educational Psychology*, 84, 435–443.

Schraw, G. (2001). Current themes and future directions in epistemological research: A commentary. *Educational Psychology Review*, 13(4), 451–664.

Schraw, G., & Sinatra, G. M. (2004). Epistemological development and its impact on cognition in academic domains. *Contemporary Educational Psychology*, 29, 95–102.

Stage, F. K., Carter, H. C., & Nora, A. (2004). Path analysis: An introduction and analysis of a decade of research. *The Journal of Educational Research*, 98(1), 5–12.

Vermetten, Y. J., Vermunt, J. D., & Lodewijks, H. G. (2002) Powerful learning environments? How university students differ in their response to instructional measures, *Learning and Instruction*, 12, 263–284.

Watkins, D. (2001). Correlates of approaches to learning: A cross-cultural meta-analysis. In R. J. Sternberg & L. F. Zhang (Eds.), *Perspectives on thinking, learning, and cognitive styles* (pp. 165–195). Mahwah, NJ: Lawrence Erlbaum.

Watkins, D. & Hattie, J. (1981). The learning processes of Australian university students: Investigations of contextual and personological factors. *British Journal of Educational Psychology*, 51, 384–393.

Watkins, D., & Hattie, J. (1985). A longitudinal study of the approaches to learning of Australian tertiary students. *Human Learning*, 4, 127–141.

Weinstein, C. E., Schulte, A., & Palmer, D. R. (1987). *The learning and study strategies inventory*. Clearwater, FL: H&H Publishing.

Zeegers, P. (2001) Approaches to learning in science: A longitudinal study. *British Journal of Educational Psychology*, 71, 115–132.

Chapter 11
Global Certainty Beliefs and College Major: How Strong Are Socialization Effects?

Ulrich Trautwein and Oliver Lüdtke

Abstract Epistemological beliefs are subjective theories of the structure and acquisition of knowledge. Using data collected early in the college career (Time 1) and two years later (Time 2) as part of a large-scale longitudinal study, the relationship between beliefs in the certainty of knowledge and choice of college major in Germany was examined. Controlling for gender, ability, and cultural capital, statistically significant differences in certainty beliefs in students with different college majors were found. Moreover, analyses controlling for Time 1 certainty beliefs showed that business students scored significantly higher on certainty beliefs than humanities students at Time 2. The results indicate that certainty beliefs are moderately shaped by enrolment in specific college majors (socialization hypothesis). The discussion critically assesses the value of global and more domain-specific indicators in research on certainty beliefs.

11.1 Introduction

Epistemological beliefs are subjective theories about the structure and boundaries of knowledge and about the nature of knowledge acquisition (Hofer & Pintrich, 1997). Sophisticated epistemological beliefs are seen as both an important goal of instruction and a key predictor of achievement (Hofer, 2001; Hofer & Pintrich, 1997; Schoenfeld, 1992). For these reasons, the last two decades have seen lively psychological discussion on the epistemological beliefs of students (for an overview, see Hofer & Pintrich, 2002) and, more recently, of teachers (e.g., Alexander et al., 1998; Sinatra & Kardash, 2004; Staub & Stern, 2002).

Despite this keen interest, and despite several important theoretical and empirical contributions to research on epistemological beliefs and their effects on thinking and learning (see Hofer & Pintrich, 1997, 2002), no consensus has yet been reached on many of the questions central to this field of research (Pintrich, 2002). One subject of ongoing debate is how epistemological beliefs relate to students' academic achievement (e.g., Wood & Kardash, 2002) and fields of study (e.g., Jehng et al., 1993).

Max Planck Institute for Human Development, Berlin, Germany

M. S. Khine (ed.), *Knowing, Knowledge and Beliefs: Epistemological Studies across Diverse Cultures.*

This chapter aims at elucidating the relationship between students' beliefs in the certainty of knowledge and their college majors. In the following section, we give a brief overview of some of the main strands of research on epistemological beliefs that are most closely related to our approach, focusing primarily on work with a background in educational psychology. In the empirical section, we report relevant results from a large-scale, longitudinal assessment of students in one of the German states.

11.2 The Certainty Dimension

The starting point of modern empirical studies of epistemological beliefs in the field of educational psychology can be traced to the work of Perry (1970). Perry studied the way university students deal with knowledge and knowledge acquisition, and how they come to grips with the uncertainties of knowledge. Based on his interviews with students, Perry developed a model describing the development of epistemological beliefs in terms of four broad developmental steps (see Hofer & Pintrich, 1997). Persons with a *dualistic view* see statements about reality as either "right" or "wrong"; in case of doubt, they assume that experts will be able to provide the correct answers. This dualistic view is succeeded by a conception of *multiplicity*, in which different views on reality are accepted. However, respondents at this stage still assume that research will eventually provide "correct" answers to unresolved questions. At the third stage, the *relativistic worldview*, all knowledge is seen as a human construction that is uncertain and that might be proven wrong; respondents at this stage believe that no one approach can be construed to be superior to another. Finally, respondents may reach the stage of *commitment within relativism* that enables them—while acknowledging that there is no certainty or absolute truth—to commit to specific views of reality and to judge the quality and appropriateness of different approaches to reality accordingly.

Perry's (1970) analyses prompted numerous studies into the development of epistemological beliefs and their relations to other constructs, and acted as a catalyst for much productive scientific discussion and debate (see Hofer & Pintrich, 2002; King & Kitchener, 1994). The development of standardized questionnaires to assess epistemological beliefs (see Duell & Schommer-Aikins, 2001, for an overview) as a parsimonious alternative to interview-based procedures was a milestone in research on epistemological beliefs. These questionnaires typically cover several dimensions. Perhaps the best-known instrument is Schommer's (1990) questionnaire on "beliefs about knowledge and learning," which covers four dimensions (stability of knowledge; structure of knowledge; speed of learning; ability to learn; see Duell & Schommer-Aikins, 2001). Hofer and Pintrich (1997) took a different approach, based on their extensive review of the literature and their thorough theoretical exploration of the dimensions used in previous research on epistemological beliefs, and argued in favor of focusing on beliefs on the *nature of knowledge* (with the subdimensions certainty of knowledge and simplicity of knowledge) and beliefs on the *nature of knowing* (with the subdimensions source of knowledge and justification of knowledge) as the core dimensions of epistemological beliefs.

The present analysis focuses on the *certainty* dimension. A strong belief in the certainty of knowledge indicates that a student believes scientific theories and results to be certain, "true," and stable. This kind of standpoint is considered to reflect an unsophisticated view of the nature and boundaries of human knowledge, and assumed to have negative consequences for learning (e.g., low-level processing). The certainty dimension is a core component of almost all conceptions of epistemological reasoning (e.g., Hofer, 2000; King & Kitchener, 1994; Schommer, 1990). It is an essential element of Perry's (1970) description of young college students who – according to his model – believe that there is a "right" answer to everything. The reflective judgment model (King & Kitchener, 1994) maps students' progression from a belief in the certainty of knowledge to a view that knowledge is uncertain and contextual. In Schommer's (1990) questionnaire, the certainty aspect is encapsulated in the "stability of knowledge" dimension (sample item: "Scientists can ultimately get to the truth"). Finally, the certainty dimension was identified in factor analyses in Hofer's empirical studies (e.g., Hofer, 2000).

11.3 The Certainty Dimension and College Majors

A small body of studies has explored the relationship between students' epistemological beliefs and their college majors. In their pioneering study, Jehng et al. (1993) administered an adapted version of Schommer's (1990) questionnaire to 386 college students from what they dubbed "hard" (engineering and business) and "soft" fields of study (humanities, social sciences). Significant group differences emerged on the certainty scale, the "omniscient authority" scale, and the "orderly process" scale. Relative to their peers with "hard" majors, students with "soft" majors were more likely to view knowledge as changeable, relied more strongly on their independent reasoning ability (rather than on authorities in the field), and experienced learning as a less orderly process. In line with Perry's (1970) assumption that the school context shapes students' epistemic thinking, Jehng et al. attributed their findings to enculturation processes: "students learn to view knowledge from the same perspective as those around them, in much the same manner that they learn correct diction or learn to distinguish couth from uncouth behavior" (Jehng et al., 1993, p. 25).

Similar differences between hard and soft fields of study were reported by Paulsen and Wells (1998), who examined 290 college students using the Schommer (1990) questionnaire and differentiating between soft versus hard and pure versus applied fields. Students majoring in soft or pure fields were less likely than others to hold naive beliefs in the certainty of knowledge. For instance, engineering students (hard, applied field) exhibited the highest certainty beliefs. In interpreting their findings, Paulsen and Wells stressed the role of disciplinary contexts as socializing agents.

The studies by Jehng et al. (1993) and Paulsen and Wells (1998) point to notable differences in the epistemological beliefs of students with different majors. However, the differences observed between hard and soft fields of study do not necessarily reflect socialization (or enculturation) effects at university. Given the cross-sectional design of the studies, it is quite possible that the differences between students majoring in different subjects were present before college entrance. In fact, different patterns of epistemological beliefs may have *caused* students to opt for certain fields of study. For instance, students with strong beliefs in the certainty of knowledge may find fields that seem to be characterized by "absolute," rather than tentative, knowledge to be more attractive. Hence, self-selection rather than socialization effects (see Pulkkinen & Caspi, 2002) may account for differences in certainty beliefs across majors.

In a recent study, Trautwein and Lüdtke (2007) attempted to empirically tease apart self-selection and socialization effects using data collected in the final year of high school and early in the college career. Findings showed that certainty beliefs predicted the choice of college major. For instance, when academic achievement, cognitive abilities, and family background were controlled, high school students aspiring to study medicine, engineering, mathematics/natural sciences, and business had statistically significantly higher certainty beliefs than those aspiring to study humanities. Data collected from the same participants two years later, when they were at college, showed that these differences were now more pronounced. This pattern of results lends support to both the self-selection and the socialization hypotheses (Pulkkinen & Caspi, 2002) with respect to certainty beliefs and college majors.

11.4 The Present Study

The present study systematically builds on and extends our previous analysis of students at the end of high school and early in the college career (Trautwein & Lüdtke, 2007) by examining students' certainty beliefs early in the college career and again two years later. Based on earlier studies that have reported students in "hard" fields to endorse certainty beliefs more strongly than students in "soft" fields (e.g., Jehng et al., 1993; Paulsen & Wells, 1998), we expected corresponding differences to emerge at both measurement points. Moreover, controlling for differences in certainty beliefs at the first point of measurement, we examined whether college major predicted certainty beliefs at the second point of measurement in order to determine whether these differences were attributable, at least in part, to socialization or enculturation effects (see Jehng et al., 1993).

11.5 Method

11.5.1 Sample

The data considered here are drawn from a large, ongoing German study, Transformation of the Secondary School System and Academic Careers (TOSCA), conducted at the Max Planck Institute for Human Development, Berlin, and the

Institute for Educational Progress at the Humboldt University, Berlin, Germany (see Köller et al., 2004, and Trautwein & Lüdtke, 2007, for more information). The study was initiated in Baden-Württemberg, one of the German states, in 2002, when the participating students were approaching the end of their upper secondary education in randomly selected traditional (90 schools) and vocational (59 schools) Gymnasium schools. Gymnasium students in Germany are a highly selected population in terms of academic achievement, and the same is true of college students (see Kitchener & Wood, 1987). Only about one third of all students in a cohort attend Gymnasium. Those awarded the Abitur school-leaving certificate from the Gymnasium are entitled to continue their education at the college level, and about 80% of Gymnasium students do so. The rest typically enter high-prestige apprenticeships.

The students in the original sample were recontacted by mail in 2004 (hereafter called Time 1) and 2006 (Time 2), and asked to complete a questionnaire in exchange for a small financial reward of 10 euros. A total of 1,775 young adults participated at both measurement points. Several of these respondents did not report a codable college major at Time 1 (N = 439, 24.7% of the sample) or Time 2 (N = 390, 22.0% of the sample). Moreover, 115 students reported a different major at Time 1 and Time 2. After excluding all participants who either did not respond at both measurement points or had changed their major, the total sample consisted of 1,086 students (63.7% female, mean age M = 24.6, SD = .84). The sample used in the present study differs from the one described in Trautwein and Lüdtke (2007) in two respects. First, we also considered students from vocational Gymnasium schools, who were excluded from the previous analyses. Second, the original student sample was sizably reduced due to dropout processes and changes of majors.

11.5.2 Instruments

Our main instrument is a measure of global certainty beliefs. In line with Trautwein and Lüdtke (2007), we further assessed several personal characteristics that may be related to students' choice of major and controlled for their effects.

11.5.2.1 Certainty Beliefs

The epistemological beliefs questionnaire administered in the TOSCA study is based on items developed by Hofer (2000) and Schommer (1990) and translated and adapted by Schiefele et al. (2002). Some new items with an explicit focus on the fallibility of scientific theories were added to give a total of seven items: "Scientific theories can be proven false at any time" (reverse scored); "Scientific theories that we presently consider to be correct can be proven false in the future" (reverse scored); "Even scientific knowledge must be revised time and again" (reverse scored); "At some stage, scientists will be able to explain the whole world"; "Scientific research shows that for most problems there is one clear-cut answer"; "Scientific laws are universal truths"; and "Scientific knowledge is unimpeachable." A four-category response format (*not true at all – somewhat not true – somewhat true – completely true*) was used. High scores indicate an overly firm belief that scientific knowledge is certain and unchangeable, whereas low scores reflect an awareness of the fallibility and changing nature of scientific theories and knowledge. Thus, in line with contemporary approaches in educational psychology, high certainty scores denote *low* sophistication of epistemic reasoning. The internal consistency (Cronbach's alpha) of the global certainty scale was .71 (Time 1) and .77 (Time 2).

11.5.2.2 Cognitive Ability

Cognitive ability or, more specifically, reasoning was measured by means of the highly g-loaded *Figure Analogies* and *Verbal Analogies* subscales from the Co*gnitive Ability Test 4–13+R* by Heller and Perleth (2000). These scales consist of 25 figural and 20 verbal items in multiple-choice format. The scales are considered to be a test of reasoning that is relatively free of environmental effects. Using the ConQuest software (Wu et al., 2000), both subscales were considered simultaneously, and scores for individual participants were estimated on the basis of item response theory. These scores indicated a good fit of the combined scale. The reliability (formula by Rost, 1996) of the score was $R_{TT} = .91$.

11.5.2.3 Final School Grades

Grades across different college majors are not comparable in Germany. We therefore used the *Abiturgesamtnote*, the final overall grade assigned to Gymnasium students, as an indicator of students' overall academic achievement. The final school grade was obtained from participants' high school records. Three elements contribute to this final school grade: test scores in a final examination held at the end of upper secondary education; school grades (or achievement points) accumulated over a two-year period in two advanced courses; and school grades accumulated over a two-year period in a number of basic courses. Thus, the final school grade is a broad index of achievement.

11.5.2.4 Family SES

Students were asked to state their parents' occupations, which were classified according to the *International Standard Classification of Occupations* (ISCO-88; ILO, 1990). The *International Socio-Economic Index of Occupational Status* (ISEI; Ganzeboom et al., 1992) was then used to transform the ISCO scores into internationally comparable ISEI scores. The higher a person's ISEI score, the higher his or her socioeconomic status. In those cases in which scores were available for both the father's and the mother's occupation, we decided to include the higher score.

11.5.2.5 Cultural Capital

We used student reports on the number of books possessed by the family as an additional indicator of the family background. A high number of books is seen as an indicator of cultural capital or learning opportunities (see Buchmann, 2002) and believed to be associated with academic outcomes. The book indicator has been successfully implemented in several large-scale educational assessments (Buchmann, 2002) in addition to – or as a substitute for – measures of family educational background, and its predictive validity for academically related behaviors and outcomes has been confirmed (e.g., TIMSS, PISA). The indicator is almost always based on student self-reports (e.g., OECD, 2001).

11.5.2.6 College Major

Students' college majors were catalogued in close conformity with the official German classification (Statistisches Bundesamt, 2001). Departing from this classification, we separated the over-inclusive category of "social sciences" into the three fields of law, business, and social sciences. We dummy-coded the seven study domains that attracted the most students, namely humanities (including languages and arts) (288), mathematics and natural sciences (225), business (154), engineering (212), social sciences (89), medicine (70), and law (48).

11.5.3 Statistical Analyses

We used the M*plus* 4.0 computer program (Muthén & Muthén, 1998–2006) to specify a set of structural equation models. Certainty beliefs were modeled as a latent variable constituted by the seven manifest indicators itemized earlier. Hence, the analyses accounted for measurement error in certainty beliefs. Following the suggestions by Marsh and Hau (1996), residual correlations between identical items at both time points were freely estimated in our longitudinal model.

The missing values estimator implemented in M*plus* was used to deal with the few missing values ($<5\%$ for all variables). M*plus* applies a model-based approach to missing data, which builds on a full information maximum likelihood estimation (see Allison, 2001, for more details on missing data).

11.6 Results

The overall level of certainty beliefs at Time 1 ($M = 1.91$, $SD = 0.39$) and Time 2 ($M = 1.90$, $SD = 0.42$) proved to be fairly low, and did not differ statistically significantly between the two measurement points, $t(1085) = 1.18$, ns. Table 11.1

Table 11.1 Intercorrelation matrix

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) Gender: female							
(2) Age	–0.04						
(3) Family SES	–0.06	–0.11					
(4) Cultural capital	0.04	–0.04	0.34				
(5) Basic cognitive abilities	–0.23	–0.09	0.07	0.17			
(6) Final school grades	0.03	–0.15	0.11	0.19	0.31		
(7) Certainty beliefs (Time 1)	–0.04	0.05	–0.07	–0.13	–0.12	–0.23	
(8) Certainty beliefs (Time 2)	–0.02	0.00	–0.06	–0.11	–0.11	–0.21	0.69

Note. All correlations > |.06| are statistically significant at $p < .05$.

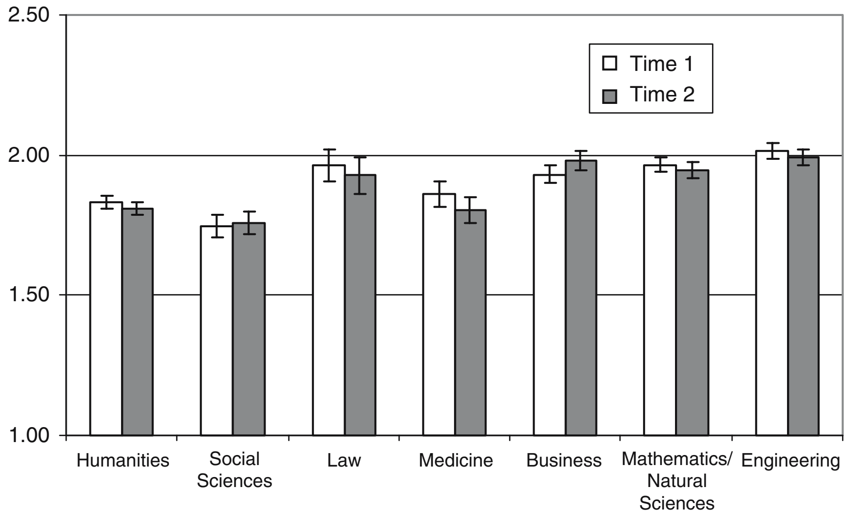


Fig. 11.1 Means and standard errors (error bars) of certainty beliefs by college major and measurement point (Time 1 versus Time 2)

shows the intercorrelation matrix of certainty beliefs at Time 1 and Time 2 with gender, age, family SES, cultural capital, basic cognitive abilities, and final school grades. There was a high correlation between certainty beliefs at Time 1 and Time 2 (r = .69). Statistically significant correlations also emerged between cultural capital (higher cultural capital was associated with lower certainty beliefs), basic cognitive abilities (higher abilities were associated with lower certainty beliefs), and final school grades (higher-achieving students had lower certainty scores).

We now turn to the relationship between students' college majors and their certainty beliefs. Figure 11.1 reports means and standard errors of certainty beliefs by measurement point (Time 1 versus Time 2) and major. At both measurement points, engineering students had the highest certainty scores and social sciences students the lowest. However, these analyses do not take account of the effects of important personal characteristics such as age, gender, basic cognitive abilities, and school achievement on the absolute level of certainty beliefs and change in these beliefs.

Using structural equation modeling, we next specified a number of models to predict Time 1 and Time 2 certainty beliefs. First, a model was specified with Time 1 certainty beliefs as the dependent variable and the college major, gender, age, family SES, cultural capital, cognitive abilities, and final school grade as predictors. College major was dummy-coded, with the largest group of humanities students being used as the reference group and the six other groups being included in the analysis. The fit of this model proved to be acceptable, $\chi^2(df = 86) = 378.78$, RMSEA = .056, SRMR =.036. Results are reported in Table 11.2 (Model 1). Fully standardized regression coefficients are given for all continuous predictor variables; the effects of all dichotomous variables are y-standardized. Hence, the regression coefficient of $b = .38$ for the group of engineering students indicates that the certainty beliefs of this group were more than one third of a standard deviation higher than those of the reference group (humanities students) when controlling for the other predictors variables in Model 1.

In Model 1, all student groups except social sciences and medicine students scored statistically significantly higher on certainty beliefs than the humanities students. Social sciences students had lower certainty beliefs than humanities students, but this difference was not statistically significant. Of the additional predictor

Table 11.2 Regression of certainty beliefs on college major, gender, age, family SES, cultural capital, cognitive abilities, final school grade, and (Model 3) Time 1 certainty beliefs

	Time 1 Certainty Beliefs	Time 2 Certainty Beliefs	
Predictors	Model 1	Model 2	Model 3
Reference category: Humanities			
Social sciences	–0.22	–0.08	0.08
Law	0.36*	0.25	–0.01
Medicine	0.30	0.09	–0.14
Business	0.30*	0.43***	0.23*
Mathematics/natural sciences	0.34**	0.30**	0.05
Engineering	0.38**	0.41***	0.11
Gender: Female	0.01	0.04	0.04
Age	0.02	–0.02	–0.03
Family SES	–0.03	–0.02	0.00
Cultural capital	–0.06	–0.03	0.00
Cognitive abilities	–0.09*	–0.06	–0.01
Final school grades	–0.19***	–0.18***	–0.04
Time 1 certainty beliefs			0.68***
R^2	0.10	0.08	0.49

Note. Effects of all dichotomous variables are y-standardized. All other effects fully standardized.

*** $p < .001$, ** $p < .01$, * $p < .05$.

variables, only cognitive abilities and final school grades significantly negatively predicted certainty beliefs.

Model 2 is an exact replication of Model 1, in which Time 1 certainty beliefs have been substituted by Time 2 certainty beliefs. Again, the fit of this model proved to be acceptable, $\chi^2(df = 86) = 483.11$, RMSEA = .065, SRMR = .037. When we controlled for personal characteristics, students majoring in business, mathematics/natural sciences, and engineering differed from the reference group (humanities students) statistically significantly. Final school grade was the only personal characteristics to significantly predict certainty beliefs at Time 2.

Finally, in Model 3, we included Time 1 certainty beliefs as an additional predictor of Time 2 certainty beliefs. The effects of the other variables can thus be understood as effects on Time 2 certainty beliefs, controlling for Time 1 certainty beliefs. This analysis allows the socialization hypotheses to be tested explicitly. Again, the fit of the model was acceptable, $\chi^2(df = 213) = 839.99$, RMSEA = .052, SRMR = .045. As shown in Table 2, certainty beliefs proved to be fairly stable ($b = .68$, $p < .001$). Nonetheless, when we controlled for Time 1 certainty beliefs and the other predictor variables, it emerged that – relative to humanities students – participants majoring in business acquired a less critical epistemological stance over time. The regression weight of the respective coefficient was $b = .23$, which can be considered a small, but meaningful effect. None of the personal characteristics statistically significantly predicted Time 2 certainty beliefs once Time 1 certainty beliefs were controlled.

11.7 Discussion

Two main results emerged from our analysis of college students' responses to a standardized questionnaire designed to assess certainty beliefs. First, we found differences in certainty beliefs across college majors, reflecting the dichotomy between "soft" and "hard" subjects, at both time points. Second, we found only limited support for the socialization hypothesis (Pulkkinen & Caspi, 2002), according to which college majors will have differential impacts on the development of certainty beliefs. Findings from a regression-based procedure that controlled for differences early in the college career showed that business students exhibited a less favorable development in certainty beliefs than did humanities students. The regression weight was of small size, however.

11.7.1 Certainty Beliefs and College Majors

Earlier studies have reported that students in hard fields tend to exhibit less sophisticated epistemological beliefs than students in soft fields (e.g., Jehng et al., 1993). Such field-specific differences may stem (see Pulkkinen & Caspi, 2002) from *self-selection processes* (students who believe more strongly in the certainty of scientific knowledge choose to study hard sciences) or from *socialization effects* (soft fields help students to acquire a critical stance as regards the “truth” of scientific theories). Previous studies have been unable to distinguish between these two processes because they were cross-sectional in design and restricted to either the high school or the college years (e.g., Jehng et al., 1993; Paulsen & Wells, 1998).

The study by Trautwein and Lüdtke (2007), which provided the starting point for the present study, found support for both the selection and the socialization perspective. Upper secondary students aspiring to different college majors differed in their certainty scores. An analysis that controlled for the impact of other potentially important variables (e.g., cognitive abilities, school grades, family background) showed that these differences could not be attributed to differences in general cognitive ability or family background. Hence, these results supported the self-selection hypothesis. Even more substantial differences were found between the seven student groups two years later, however, when they had started college, reflecting the well-known dichotomy between “hard” and “soft” subjects.

Our overall pattern of results thus indicates that certainty beliefs are associated with students’ choices of college major (selection hypothesis), that changes in certainty beliefs are systematically associated with their major in the early semesters at college (socialization hypothesis), but that the association between college major and development of certainty beliefs becomes less strong later on. One might speculate that students’ beliefs about knowledge and knowledge acquisition in their majors are formed early in their college careers, be it as a consequence of explicit instruction about the sources and boundaries of knowledge acquisition in their fields or by an implicit adoption of prevalent belief structures. Unfortunately, our design did not allow us to examine the learning environments and underlying processes that may have led to any socialization effects.

11.7.2 Limitations and Suggestions for Future Research

How strongly are certainty beliefs associated with college students’ educational environments? The two-year longitudinal design of our study permitted a stronger test of the socialization hypothesis than was possible in previous studies with single-measurement designs (e.g., Jehng et al., 1993). However, some important limitations of our study should also be noted. First, in terms of the Hofer and Pintrich (1997) classification, the certainty scale we used refers primarily to beliefs about the “nature of knowledge” and, more specifically, to the certainty dimension.

This was the only dimension of epistemological beliefs covered in the large-scale study from which our data were drawn. In a similar vein, our study was restricted to a measure of *global* certainty and did not address domain-specific epistemological beliefs. However, recent research (Buehl, Alexander, & Murphy, 2002; Hofer, 2000; Trautwein & Lüdtke, 2007) has highlighted the value of conceptualizing epistemological beliefs as both domain-specific and domain-general beliefs about the structure of knowledge and the nature of knowledge acquisition. We hope that future longitudinal studies on the transition from high school to college will be able to incorporate a broader set of variables than was used in the present context.

Second, our study does not allow the processes that shape certainty beliefs to be examined in more detail. Hence, we did not address the question of how certainty beliefs are shaped by specific academic environments and the way these certainty beliefs impact on achievement and academic choices. More research in this area is clearly required.

Third, questionnaire measures are just one approach to the assessment of epistemological beliefs (see Hofer & Pintrich, 2002, for an overview), and have been subject to a certain amount of criticism (e.g., Bromme, 2005; Trautwein & Lüdtke, 2007; Wood & Kardash, 2002). The decontextualized nature of the global measure is a potential limitation in the context of choice of college major. Although students majoring in different subjects complete the same questionnaire, they might use a different frame of reference when responding to the items. Whereas some students will respond with reference to scientific theories from empirical sciences, others might have philosophical reasoning in mind.

In other words, standardized questionnaires employed to tap global epistemological beliefs leave it to the respondent to decide precisely which theories to base their response upon. Yet responses to these items are treated as general statements about the boundaries of human knowledge and knowledge acquisition, and assessed in terms of their sophistication. Because this aspect is not controlled when using global certainty scales, it is possible that the items in fact mean different things to students with different majors. This is not a problem per se – in fact, the frame of reference chosen by students in different fields is an interesting question in itself. However, it may be a source of unwanted variance when tapping global epistemological beliefs. To tease such influences apart, Trautwein and Lüdtke (2007) asked respondents to complete a global measure of certainty beliefs as well as a measure that tapped topic-specific certainty beliefs (e.g., "Is big bang theory correct?"). They found the predictive effect of college major to be considerably stronger for global certainty beliefs than for topic-specific beliefs.

Another way of "fixing" the respondents' frame of reference is to use a contextualized, topic-based assessment strategy, such as that implemented in the reflective judgment interview (RJI) by King and Kitchener (1994; see review by Wood, 1997). Unfortunately, the use of these instruments is extremely resource-intensive, because participant responses must be obtained by individual interviews and then transcribed and coded by multiple raters. Hence, these instruments are not suitable for large-scale studies. However, tests of epistemic reasoning have recently developed that translate the problem-based assessment procedure used in the RJI into a paper-and-pencil framework (see Krettenauer, 2004). This development will provide an additional approach to testing the relationship between epistemological beliefs, academic achievement, and college major.

A final, related point concerns the increasing dissatisfaction with the available questionnaire instruments. As highlighted by Bromme (2005), the quality of the questionnaires may in some cases compare unfavorably with the sophistication of the respondents' beliefs. Researchers with a profound knowledge of philosophical theorizing on knowledge and knowledge acquisition will doubtless object to many of the items used in measures of epistemological beliefs such as ours. We believe that, in its efforts to develop better research instruments, educational psychology can profit immensely from the conceptual advances that have been made in the fields of modal logic and epistemic logic in recent decades (see Piéraut-Le Bonniec, 1980; Sainsbury, 1991).

Note: The data presented come from the large-scale TOSCA study on the Transformation of the Secondary School System and Academic Careers, jointly conducted by the Center for Educational Research at the Max Planck Institute for Human Development, Berlin, Germany, and the Institute for Educational Progress at the Humboldt University, Berlin, Germany. The TOSCA study is supported by a grant from the German Research Foundation (Ko 1513/6–1). The authors thank Susannah Goss for editorial assistance.

References

Alexander, P. A., Murphy, P. K., Guan, J., & Murphy, P. A. (1998). How students and teachers in Singapore and the United States conceptualize knowledge and beliefs: Positioning learning within epistemological frameworks. *Learning and Instruction*, 8, 97–116.

Allison, P. D. (2001). *Missing data*. Thousand Oaks, CA: Sage.

Bromme, R. (2005). Thinking and knowing about knowledge: A plea for and critical remarks on psychological research programs on epistemological beliefs. In M. Hoffmann, J. Lenhard, & F. Seeger (Eds.), *Activity and sign: Grounding mathematics education* (pp. 191–201). New York: Springer.

Buchmann, C. (2002). Measuring family background in international studies of education: Conceptual issues and methodological challenges. In A. C. Porter and A. Gamoran (Eds.), *Methodological advances in cross-national surveys of educational achievement* (pp. 150–197). Washington, DC: National Academy Press.

Buehl, M. M., Alexander, P. A., & Murphy, P. K. (2002). Beliefs about schooled knowledge: Domain specific or domain general? *Contemporary Educational Psychology*, 27, 415–449.

Duell, O. K., & Schommer-Aikins, M. (2001). Measures of people's beliefs about knowledge and learning. *Educational Psychology Review*, 13, 419–449.

Ganzeboom, H. B. G., De Graaf, P. M., Treiman, D. J., & De Leeuw, J. (1992). A standard international socio-economic index of occupational status. *Social Science Research*, 21, 1–56.

Heller, K. A., & Perleth, C. (2000). *Kognitiver Fähigkeitstest für 4. bis 12. Klassen, Revision* [Cognitive Ability Test for grades 4 to 12, revised version]. Göttingen, Germany: Hogrefe.

Hofer, B. K. (2000). Dimensionality and disciplinary differences in personal epistemology. *Contemporary Educational Psychology*, 25, 378–405.

Hofer, B. K. (2001). Personal epistemology research: Implications for learning and teaching. *Educational Psychology Review*, 13, 353–383.

Hofer, B. K., & Pintrich, P. R. (1997). The development of epistemological theories: Beliefs about knowledge and knowing and their relation to learning. *Review of Educational Research*, 67, 88–140.

Hofer, B. K., & Pintrich, P. R. (Eds.). (2002). *Personal epistemology: The psychology of beliefs about knowledge and knowing*. Mahwah, NJ: Lawrence Erlbaum.

ILO – International Labour Office (Ed.). (1990). *International Standard Classification of Occupations. ISCO-88*. Geneva: ILO.

Jehng, J. -C., Johnson, S. D., & Anderson, R. C. (1993). Schooling and students' epistemological beliefs about learning. *Contemporary Educational Psychology*, 18, 23–35.

King, P. M., & Kitchener, K. S. (1994). *The development of reflective judgment in adolescence and adulthood*. San Francisco, CA: Jossey-Bass.
Kitchener, K. S., & Wood, P. K. (1987). Development of concepts of justification in German university students. *International Journal of Behavioral Development*, 10, 171–185.
Köller, O., Watermann, R., Trautwein, U., & Lüdtke, O. (2004). *Wege zur Hochschulreife in Baden-Württemberg. TOSCA – Eine Untersuchung an allgemein bildenden und beruflichen Gymnasien* [Educational pathways to college in Baden-Württemberg. TOSCA – A study at upper secondary level of traditional and vocational Gymnasium]. Opladen, Germany: Leske + Budrich.
Krettenauer, T. (2004). Metaethical cognition and epistemic reasoning development in adolescence. *International Journal of Behavioral Development*, 68, 461–470.
Marsh, H. W., & Hau, K. -T. (1996). Assessing goodness of fit: Is parsimony always desirable? *Journal of Experimental Education*, 64, 364–390.
Muthén, L. K., & Muthén, B. (1998–2006). *Mplus 4.0* [Computer Program] . Los Angeles, CA: Muthén & Muthén.
OECD (2001). *Knowledge and skills for life. First results from the OECD Programme for international student assessment (PISA) 2000*. OECD, Paris: Author.
Paulsen, M. B., & Wells, C. T. (1998). Domain differences in the epistemological beliefs of college students. *Research in Higher Education*, 39, 365–384.
Perry, W. G. (1970). *Forms of intellectual and ethical development in the college years: A scheme*. New York: Holt (Rinehart & Winston).
Piéraut-Le Bonniec, G. (1980). *The development of modal reasoning*. New York: Academic Press.
Pintrich, P. (2002). Future challenges and directions for theory and research on personal epistemology. In B. K. Hofer & Paul R. Pintrich (Eds.), *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 389–414). Mahwah, NJ: Erlbaum.
Pulkkinen, L., & Caspi, A. (Ed.) (2002). *Paths to successful development: Personality in the life course*. New York, NY: Cambridge University Press.
Rost, J. (1996). *Lehrbuch Testtheorie, Testkonstruktion* [Test theory and test construction]. Bern, Switzerland: Huber.
Sainsbury, M. (1991). *Logical forms. An introduction to philosophical logic*. Oxford: Blackwell.
Schiefele, U., Moschner, B., & Husstegge, R. (2002). *Skalenhandbuch SMILE-Projekt* [Documentation of the scales used in the SMILE project]. Bielefeld, Germany: Universität, Abteilung für Psychologie.
Schoenfeld, A. H. (1992). Learning to think mathematically: Problem solving, metacognition, and sense making in mathematics. In D. A. Grouws (Ed.), *Handbook of research on mathematics, teaching and learning* (NCTM) (pp. 334–370). New York: Macmillan.
Schommer, M. (1990). Effects of beliefs about the nature of knowledge on comprehension. *Journal of Educational Psychology*, 82, 498–504.
Sinatra, G. M., & Kardash, C. M. (2004). Teacher candidates' epistemological beliefs, dispositions, and views on teaching as persuasion. *Contemporary Educational Psychology*, 29, 483–498 .
Statistisches Bundesamt (2001). *Bildung und Kultur. Studierende an Hochschulen. Fachserie 11, Reihe 4.1* [Education and culture. Students in higher education. Series 11, number 4.1]. Stuttgart, Germany: Metzler-Poeschel.
Staub, F., & Stern, E. (2002). The nature of teachers' pedagogical content beliefs matters for students' achievement gains: Quasi-experimental evidence from elementary mathematics. *Journal of Educational Psychology*, 93, 144–155.
Trautwein, U., & Lüdtke, O. (2007). Epistemological beliefs, school achievement, and college major: A large-scale, longitudinal study on the impact of certainty beliefs. *Contemporary Educational Psychology,* 32, 348–366.
Trautwein, U., & Lüdtke, O. (in press). Predicting global and topic-specific certainty beliefs: Domain-specificity and the role of the academic environment. *British Journal of Educational Psychology*.
Wood, P. K. (1997). A secondary analysis of claims regarding the Reflective Judgment Interview: Internal consistency, sequentiality and intraindividual differences in ill-structured problem

solving. In J. C. Smart (Ed.), *Higher education: Handbook of theory and research*, Vol. XII (pp. 245–314). Edison, NJ: Agathon.

Wood, P. K., & Kardash, C. A. (2002). Critical elements in the design and analysis of studies of epistemology. In B. K. Hofer & Paul R. Pintrich (Eds.), *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 231–260). Mahwah, NJ: Erlbaum.

Wu, M., Adams, R. J., & Wilson, M. (2000). *ACER ConQuest. Generalised item response modeling software manual*. Melbourne, Australia: ACER.

Chapter 12
Epistemological Beliefs, Learning, and Teaching: The Hong Kong Cultural Context

Kwok-wai Chan

Abstract Since the last two decades, there have been increasing interests and researches on epistemological beliefs, including the theoretical framework, dimensional structure, and the relations with metacognitive variables in learning. Many of the researches on epistemological beliefs were conducted in Western countries, mainly North America, with few studies in non-Western countries such as the Chinese culture (Chan & Elliott, 2004a). The varied number and nature of epistemological belief dimensions reported in literature suggest the cultural specificity of epistemological beliefs, and the need to conduct more epistemological beliefs research in different cultures to enable us a better understanding of the beliefs structure (Hofer & Pintrich, 1997). The identified relation between epistemological beliefs and reading comprehension (Schommer, 1994) highlight the relative importance of epistemological beliefs in students' learning. As well, the relations between epistemological beliefs and other metacognitive variables, such as learning strategies, motivation, conceptions about learning and teaching, etc., definitely are significant in helping us understand student learning and these studies would shape the future direction of epistemological beliefs research. Studies of this nature in different cultural contexts would also provide valuable information for researchers and educators. In light with this, the present paper reports the author's research in epistemological beliefs, and the relations with metacognitive variables in learning and teaching in the Hong Kong Chinese cultural context. The research includes the development of a validated epistemological beliefs scale with satisfactory psychometric properties, relational analyses of epistemological beliefs and learning approaches/strategies, and conceptions of teaching and learning. The information is expected to add new knowledge in this area and be of value to those interested in epistemological beliefs research.

The Hong Kong Institute of Education, Hong Kong SAR, People's Republic of China

M. S. Khine (ed.), *Knowing, Knowledge and Beliefs: Epistemological Studies across Diverse Cultures.*

12.1 Introduction

There have been increasing interests and researches in epistemological beliefs since the late 1990s. Several lines of epistemological research can be found in literature including the nature and structure of epistemological beliefs (Chan & Elliott, 2004a; Hofer & Pintrich, 1997, 2002; Schommer, 1990, 1994), the development of epistemological beliefs and reflective thinking (King & Kitchener, 1994, 2002; Perry, 1968; Schommer, 1993), whether epistemological beliefs are domain specific or general (Hofer, 2000; Paulsen & Wells, 1998; Schommer & Walker 1995; Schommer et al., 2003) and the relations of epistemological beliefs with metacognitive variables such as text comprehension, problem solving, motivation, learning strategies (Cano, 2005; Chan, 2003; Paulsen & Feldman, 1999; Ryan, 1984; Schoenfeld, 1985; Schommer, 1990, Schraw & Olafson, 2002) and conceptual change (Mason & Boscolo, 2004).

Many of the epistemological beliefs studies were conducted in Western countries, mainly in North America and there were few studies found in non-Western countries such as the Chinese culture. For research on epistemological beliefs, Schommer could be considered a pioneer because she had initiated a more quantitative and analytical approach to measure epistemological beliefs than her predecessors who usually used more complex, time-consuming measures such as production tasks and/or interviews. Stimulated by the early work of Perry (1968) on the developmental stages of epistemology of university undergraduates in North America, Schommer proposed a theoretical framework of five epistemological dimensions and conceptualized them as a system of more or less independent beliefs. The proposed five dimensions were associated with the source, certainty, structure, control and speed of knowledge and knowledge acquisition. Correspondingly, the five dimensions were labelled by Schommer "Omniscient Authority", "Certain Knowledge", "Simple Knowledge", "Innate/Fixed Ability" and "Quick Learning" (Schommer, 1990, 1994). Based on her conceptual framework, Schommer developed a 63-item epistemological beliefs questionnaire, comprising 12 subscales and conducted studies with university students in North America in the early 1990s. Schommer (1990) reported that she was able to extract four dimensions of epistemological beliefs out of the five hypothetical beliefs in exploratory factor analysis, and that the dimension "Omniscient Authority" was not identified.

In addition, Schommer (1990) pointed out the relations of epistemological beliefs with meta-cognitive variables such as text comprehension. The work of Schommer has inspired other researchers to inquire along similar direction of research in epistemological beliefs (e.g., Kardash & Scholes, 1996; Jehng et al., 1993; Qian & Alvermann, 2000). The controversial findings reported in literature have raised inquiries and arguments on epistemological beliefs structure and measurement, including the reliabilities of the scale items developed by Schommer, and the methodology employed in the measurement of epistemological beliefs, hence leading to different design and development of scales for epistemological beliefs measurement (Clarebout et al., 2001; Chan & Elliott, 2000, 2002; Schraw et al., 2002; Wood & Kardash, 2002). Following these, different models or theoretical framework about the dimensional structure of epistemological beliefs as well as suggested methodology and future direction of research in epistemological beliefs could be found in literature (Chan & Elliott, 2004a; Hofer & Pintrich, 1997; Schraw, 2001; Schraw & Olafson, 2002). Through literature review and synthesis of varied research findings, the author of this paper has been able to propose a plausible model for the structure and nature of epistemological beliefs to account for different belief dimensions reported in literature (Chan, 2006).

These include, first, epistemological beliefs are multidimensional and culture-specific (Arredondo & Rucinski, 1996, Chan & Elliott, 2004a; Youn, 2000). Second, epistemological beliefs have significant role to play in learning and teaching as evidenced by the research findings reported in literature. In fact, epistemological beliefs have been found to be related to text comprehension, problem solving, motivation, and learning strategies (Paulsen & Feldman, 1999; Ryan, 1984; Schommer, 1990, 1994; Schommer et al., 1992). There are some other metacognitive variables in learning and teaching which are possibly related to epistemological beliefs, such relationships are worth to be explored in future research. The findings would help us understand the impact of epistemological beliefs on students' learning and achievement besides factors such as motivation, attribution, and self-efficacy. Also, epistemological beliefs are expected to be related to the conceptions about learning and teaching, subsequently, influence classroom teaching and learning.

In line with the above, this paper reports a series of studies of epistemological beliefs conducted by the author with Chinese undergraduate students in a university in Hong Kong. The studies would provide updated information and findings of epistemological beliefs research in the Hong Kong Chinese context, which is lacking in the current literature. The studies are significant in that the findings support the notion of cultural specificity of epistemological beliefs, provide new knowledge about the structure and nature of epistemological beliefs. In addition, the studies also highlight the relations between epistemological beliefs and learning approaches/ strategies, and conceptions about teaching and learning. The studies reported in this paper not only support literature findings that epistemological beliefs are related to metacognitive variables in learning such as text comprehension but also expand the scope of research and add new knowledge in this area which has not been examined. Thus, the results provided in this paper are likely to be helpful to interested parties in epistemological beliefs research, especially in the Hong Kong Chinese culture and may extend to similar lines of research in other cultural contexts.

To fulfil the above purposes, the paper is divided into three sections. The first section is on the development of a valid and reliable instrument or scale to measure epistemological beliefs for Hong Kong Chinese students, which is a prerequisite step for epistemological beliefs research in the local context. The scale is developed through adaptation of available instruments developed in the West, for example, the Schommer 63-item scale in North America. The second section is about the identified dimensions of epistemological beliefs and the multivariate analysis of epistemological beliefs with respect to demographic variables such as gender and age. The third section is on the relational analysis of epistemological beliefs with metacognitive variables in learning, including learning approaches/strategies, conceptions of teaching/personal theories about teaching, and conceptions of learning. Based on the results of a series of studies conducted by the author, implications and suggestions are drawn for future research on epistemological beliefs.

12.2 Development of a Validated Epistemological Beliefs Scale

To examine the epistemological beliefs of teacher education students in a Hong Kong university, the author adapted the 63-item epistemological questionnaire developed by Schommer (1990) and to test its applicability in the Hong Kong Chinese context. The questionnaire was translated into Chinese, moderated and discussed by a panel of two Chinese lecturers who were experienced in teaching Educational Psychology in both the English and Chinese courses. Pilot studies were conducted with a group of students in the two-year Certificate in Education Course (equivalent to university undergraduates in entry qualification) to check its comprehension and face validity. The 63-item questionnaire was administered to 385 teacher education students on a 5-point Likert rating scale. Using the 12 conceptual subscales proposed by Schommer in exploratory factor analysis, three factors were extracted with eigenvalue equal or greater than 1, and the fourth factor loaded at eigenvalue of .98, the same as what Schommer did and obtained (1990). Psychometric properties analysis of the 12 subscales yielded low to very low reliability alpha values (Chan & Elliott, 2000). Therefore the author decided to factor analyse the 63 items instead of the 12 conceptual subscales With iterative process of factor analysis, item identification, revision and deletion, it ended up with a scale of 30 items, comprising four dimensions/subscales, viz. "Authority/Expert Knowledge", "Certainty Knowledge", "Innate/Fixed Ability", and "Learning Effort/Process". The internal consistency of the four extracted factors/subscales was satisfactory (Cronbach alphas range from .6 to .7). The 30-item extracted scale was validated by confirmatory factor analysis with satisfactory goodness of fit index obtained (GFI = .93, AGFI = .90, RMSEA = .058, RMR = .064). The developmental details of the epistemological beliefs questionnaire or scale were reported elsewhere (Chan & Elliott, 2002). Later studies by the author with students of degree programme also replicated the four factor structure with alpha values ranging from .62 to .70, acceptable for research purpose (Chan, unpublished data).

12.3 Epistemological Beliefs of Hong Kong Teacher Education Students

The four factors or dimensions identified in the studies with Hong Kong teacher education students in someway resembled to and differed from that of Schommer's studies of North America undergraduates, reflecting the cultural aspect of epistemological beliefs. Two dimensions are similar to that of Schommer's, viz. "Certainty Knowledge" and "Innate/Fixed Ability", and Schommer labelled the former factor "Certain Knowledge". These two factors or dimensions are related to the structure and nature of knowledge and control of knowing respectively. The other two dimensions are different and were labelled by the author "Authority/Expert Knowledge" (related to the source of knowledge) and "Learning Effort/Process" (related to learning process requiring effort and understanding). The results, especially the extraction of the dimension "Authority/Expert Knowledge" and "Learning Effort/Process", reflect the possible influence of different cultural contexts on epistemological beliefs. In this case the differences were between a Hong Kong Chinese (non-Western) context and the North American (Western) cultural contexts as reported in Schommer's studies. In terms of the mean scores of the four factors/dimensions (out of a 5-point rating scale), the Hong Kong teacher education students tended to believe that knowledge is acquired through one's effort and the learning process (mean = 3.92) rather than being handed down by authority figures or experts (mean = 2.62). The Hong Kong teacher education students also tended not to believe that ability is inborn and fixed (mean = 2.82); and they tended not to believe that knowledge is certain and unchanged (mean = 2.62) (see Chan & Elliott, 2002).

The value system in traditional Chinese culture could be one possible factor to account for the relative high mean score found in the epistemological belief dimension, "Learning Effort/Process". Confucian Chinese culture placed high value on education, effort, and hardwork. To the Chinese, education and learning have always been associated with effort. Effort or hardwork is considered a very important attribute of a person's success, especially for academic achievement. This has been demonstrated in a number of attribution studies with Hong Kong Chinese students (e.g., Hau & Salili, 1990, 1996). Chinese children are reared in an environment where effort, endurance, and hardwork are emphasized. People who attempt tasks beyond their ability are admired and commended, rather than ridiculed. "Knowing the impossibility of accomplishment but still working hard" is a highly praised virtue. People tend to emphasize the importance of effort rather than effort (Lau, 1996). The Hong Kong teacher education students represent a general "Chinese" orientation to beliefs associated with learning. Many of them are inclined towards working hard and learning how to learn. This may account for the highest mean subscale score and smallest deviation within the respondents in favour of "Learning Effort/Process" in this study.

The extraction of the dimension "Authority/Expert Knowledge" indicates the significance of the belief in "Authority" in traditional Chinese culture. In such a culture, students are expected to show respect for, and be obedient, to elders and authority figures. It is expected that authority figures or experts hand down knowledge. Confucianism has influenced the Chinese beliefs and thoughts in education for a long time, teachers and educators are considered and respected as the source of knowledge. Similarly, factor close to "Authority/Expert Knowledge" was also reported in epistemological belief studies in Asian collectivistic culture, such as Korea (Lee, 1995), Taiwan (Lin, 2001), which are influenced greatly by the traditional Chinese values and beliefs. Nevertheless, Confucianism may be too narrow a focus for understanding the behaviour of Hong Kong Chinese people. Have been a British colony for over a hundred years and continually exposed to Western thoughts and cultures before and after the return of sovereignty to China in 1997, the interaction of the traditional Chinese culture and philosophy with western influences might be an explanation for the relatively lower mean score and large range (minimum 1.00 and maximum 4.67) in the belief of "Authority/Expert Knowledge" compared to those of "Learning Effort/ Process" and "Innate/Fixed Ability".

The finding that Hong Kong teacher education students tended not to believe in "Certainty Knowledge" are similar to the North America university undergraduates in studies conducted by researchers such as Perry (1968), Ryan (1984), and Schommer (1990, 1993) in that as students grow older and develop, they start to adopt a more sophisticated viewpoint toward knowledge and believe knowledge is changing and tentative. Some students under study were in a transition stage of development of epistemological beliefs and some had already passed through the naïve stage. Thus, there was a spread of beliefs within the students. Since the majority of the students (92.7%) were in the age range of 20–25 and about 1.6% below 20, this might account for the relatively lower mean value (2.62) concerning the belief that knowledge is certain and unchanging. For details, see Chan and Elliott (2004b).

12.4 Relations of Epistemological Beliefs with Learning Approaches and Strategies

Review of literature on student learning indicates that the Presage factor: student characteristics, including motivation, conceptions, and beliefs have strong influence on the approaches and strategies adopted by the student, and subsequently affect the learning outcome and achievement (see 3P model in Biggs & Moore, 1993). Recently, there has been expanding research on the relations between epistemological beliefs and motivation and learning approaches and strategies of students at both university and secondary level (Cano, 2005; Paulsen & Feldman, 1999; Paulsen & Gentry, 1995). In these studies, students' epistemological were found related to their motivational beliefs, cognitive strategies, and learning outcomes (Hofer & Pintrich, 1997). For example, in the study by Paulsen and Feldman

(1999), students with naïve belief that the structure of knowledge is simple were less likely to have an intrinsic goal orientation, to appreciate the value of learning tasks, to perceive an internal control over learning, and to feel efficacious about their capacity to learn. Instead, they were more likely to have an extrinsic goal orientation and to experience higher levels of test anxiety than students with more sophisticated beliefs. Students with naïve belief in quick learning were less likely to have an intrinsic goal orientation, to appreciate the value of learning tasks, and to perceive an internal control over learning. They were also more likely to have an extrinsic goal orientation toward learning. Students with naïve belief that ability to learn is fixed were less likely to have an intrinsic goal orientation, to appreciate the value of learning tasks, to perceive an internal control over learning, and to feel efficacious about their capacity to learn. In a study of Spanish high school students, Cano (2005) reported a direct effect of epistemological beliefs on academic achievement as well as an indirect effect mediated by approaches to learning.

Studies of the relations between epistemological beliefs and learning approaches/ strategies in the Chinese culture were not found in literature and this has stimulated the author to conduct such studies in 2003 and afterwards. In a study conducted by the author with a sample of Hong Kong teacher education students (Chan, 2003), using the epistemological beliefs questionnaire developed by the author (Chan & Elliott, 2002) and the Study Process Questionnaire developed by Biggs (1987), it was found that there were significant relations between the four epistemological belief and three study approach dimensions. The epistemological belief dimension "Innate/Fixed Ability" was positively related to "Surface Approach", "Learning Effort/Process" was positively related to "Deep Approach", "Authority/Expert Knowledge", while positively related to "Surface Approach", was found negatively related to "Deep Approach"; "Certainty Knowledge" was positively related to both "Surface" and "Achieving Approach". The findings provide support to the notion that epistemological beliefs could mediate the academic performance through interaction with cognition and activities such as study approaches and strategies. A possible relation between epistemological beliefs and goal orientations is also likely to exist, which influences the learner to adopt certain types of study approaches and strategies, leading to a predicable academic performance. More research in these areas probably would produce fruitful results in explaining the learning behaviour and outcomes of students.

Recently, the author conducted another study with another sample of Hong Kong teacher education students in the degree programme, using the epistemological beliefs questionnaire and the revised two-factor study process questionnaire developed by Biggs and associates (Biggs et al., 2001). It was found that "Authority/Expert Knowledge", "Certainty Knowledge" and "Innate/Fixed Ability" were significantly and positively related to "Surface Strategy", whereas, "Learning Effort/Process" was significantly and positively related to "Deep Strategy". "Innate/Fixed Ability", on the other hand was negatively and significantly related to "Deep Strategy". The correlations were from moderate to moderately low (Chan, unpublished data). The results were similar to the early study conducted by Chan with sub-degree students in

2003. All these studies indicated the close relations between epistemological beliefs and learning approaches/strategies.

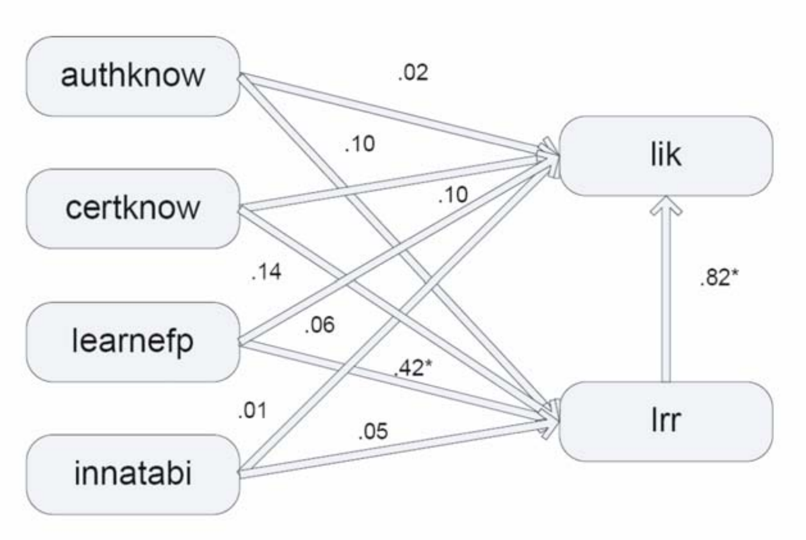
12.5 Relations of Epistemological Beliefs with the Traditional and Constructivist Conceptions about Teaching and Learning

Research has shown that teachers' classroom behaviour and practices are shaped by the teachers' beliefs about teaching and learning, the teachers' beliefs are known by various labels such as implicit theories, practical theories, conceptions, images, and metaphors (Calderhead, 1996; Marland, 1998; Richardson, 1996). For everyday interactions with students, a teacher has to make many decisions that influence his/her behaviour. Such decision making is meta-cognitive in nature and is probably affected by the classroom context and the teacher's beliefs about the nature of knowledge and knowledge acquisition, such as what knowledge is relevant and important to be taught in a lesson and what learning process is suitable for students to acquire the expected knowledge (Ennis et al., 1997; Pajares, 1992). Thus, there may exist certain relations between teachers' epistemological beliefs and their conceptions about teaching and learning, subsequently leading to different approaches and strategies adopted in classroom teaching. In the past, teachers' beliefs or conceptions about teaching and learning were usually studied in a qualitative manner, such as through interview and narratives and no empirical study data of the relations between teachers' epistemological beliefs and conceptions about teaching and learning in a quantitative manner was available in the literature. The author attempted a quantitative study of such relationship for a sample of preservice teacher education students in Hong Kong, making use of two scales or questionnaires developed and validated by the author. The first questionnaire was a 30-item epistemological beliefs questionnaire (EBQ) which measured four dimensions of epistemological beliefs (as mentioned earlier) and the second questionnaire was the 30-item teaching and learning conceptions questionnaire (TLCQ) which measured the "Traditional Conception" and "Constructivist Conception" of teaching and learning. Structural modelling and path analysis were applied to study the relationships between epistemological beliefs and the traditional and constructivist conceptions about teaching and learning. It was found that epistemological beliefs including "Innate/Fixed Ability", "Authority/Expert Knowledge", and "Certainty Knowledge" were related to and had significant effects on "Traditional Conception" while epistemological beliefs such as "Learning Effort/Process" was significantly and but negatively related to "Constructivist Conception". The relations were explained in terms of the traditional Chinese culture and Confucianism that place value on hardwork and effort, abide to authority, the beliefs that ability is changeable by effort and the nature of traditional and constructivist conceptions about teaching and learning. The details of the study were reported in literature (Chan & Elliott, 2004b).

12.6 Relations of Epistemological Beliefs with Quantitative and Qualitative Conceptions about Learning

Inspired by the findings, the author continued to examine the relations between epistemological beliefs and the quantitative and qualitative conceptions about learning held by another sample of 231 preservice teacher education students in 2006 (Chan, unpublished data). Learning could be conceived in a quantitative or qualitative perspective. The quantitative conception refers to the amount or quantity of knowledge gained and reproduced. The qualitative conception refers to change in personal views through learning, and understanding of the acquired knowledge (Biggs & Moore, 1993; Marton et al., 1993; Purdie & Hattie, 2002). The conceptions of learning are usually assumed to exist in a hierarchy with the interpretive/constructivist view of learning at the upper level and the acquisition/reproduction view of learning at the lower level (Marton et al., 1993; Purdie & Hattie, 2002).

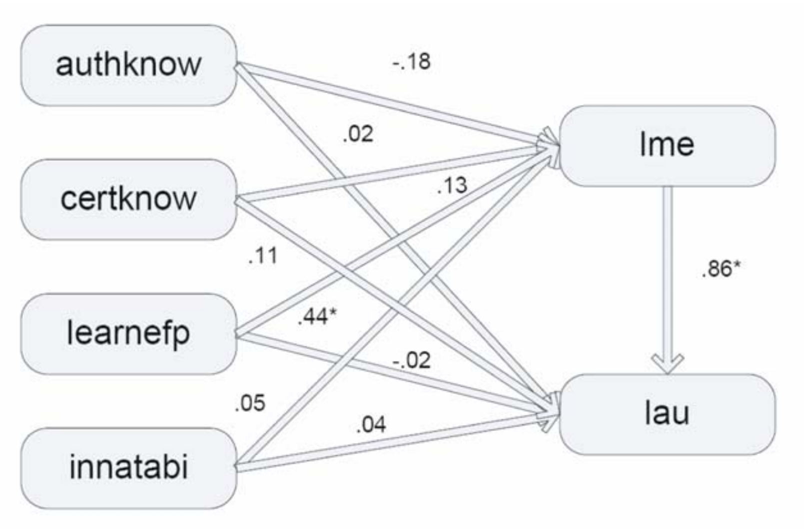
While the same epistemological beliefs scale (EBQ) developed by the author was used to examine the epistemological beliefs, a scale called Conceptions of Learning (COLI) developed by Purdie and Hattie (2002) was used to measure nine dimensions of



*<.05
Note:
authknow =Authority/Expert knowledge
certknow = Certainty knowledge
learnefp = Learning effort/process
innatabi = Innate/Fixed ability
lik = Learning as increase in knowledge
lrr = Learning as remembering and reproducing

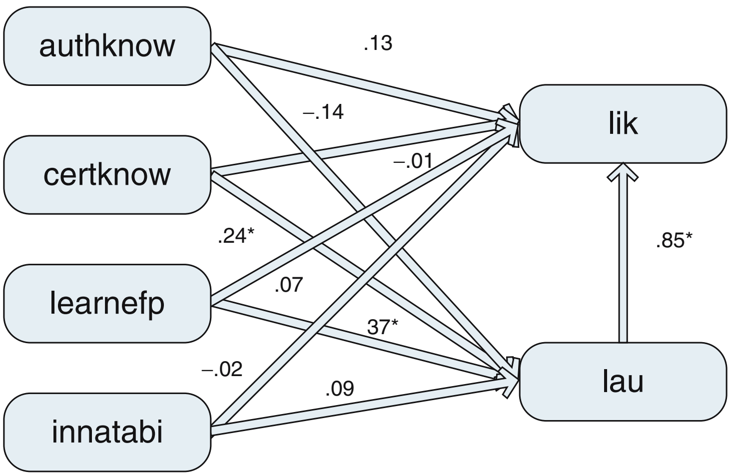
Fig. 12.1 Path diagram with standardized estimates of coefficients for epistemological beliefs and quantitative conceptions about learning (M1) conceptions about learning. The scale consisted of 45 items and was validated and reported in literature to have satisfactory goodness of fit index and psychometric properties (NNFI = .98 and RMSEA = .05). The nine dimensions were “Learning as an increase in knowledge”, “Learning as remembering and reproducing”, “Learning as a means to an end”, “Learning as understanding”, “Learning as seeing something in a different way”, “Learning as personal fulfilment”, “Learning as a duty”, “Learning is process not bound by time or context”, and “Learning as developing social competence”.

Pearson correlation analysis showed significant pairs of relations between epistemological beliefs and conceptions of learning. For example, “Authority/Expert Knowledge” was negatively related to “Learning as a means to an end”, and “Learning as seeing something in a different way”. The epistemological beliefs dimension “Learning Effort/Process” was positively and significantly related to all nine dimensions of conceptions about learning, and the magnitude of correlation was from moderate to moderately high. “Innate/Fixed Ability” was found to be negatively and significantly related to three conception dimensions: “Learning as seeing something different”, “Learning as personal change”, and “Learning as developing social competence”. “Certainty Knowledge” was found positively and significantly related to the three conception dimensions, viz: “Learning as an increase in knowledge”, “Learning



* < .05
Note:
authknow =Authority/Expert knowledge
certknow = Certainty knowledge
learnefp = Learning effort/process
innatabi = Innate/Fixed ability
lau = Learning as understanding
lme = Learning as a means to an end

Fig. 12.2 Path diagram with standardized estimates of coefficients for epistemological beliefs and qualitative conceptions about learning (M2)



* < .05
Note:
authknow =Authority/Expert knowledge
certknow = Certainty knowledge
learnefp = Learning effort/process
innatabi = Innate/Fixed ability
lik = Learning as increase in knowledge
lau = Learning as understanding

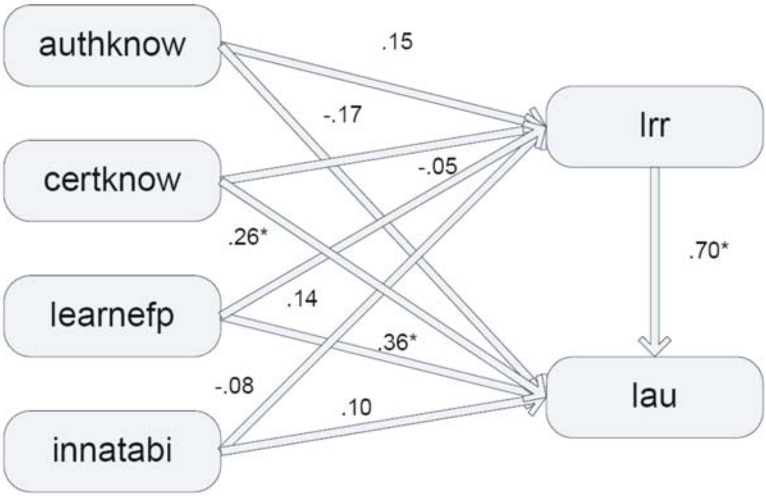
Fig. 12.3 Path diagram with standardized estimates of coefficients for epistemological beliefs and quantitative plus qualitative conceptions about learning combination 1(M3)

as remembering and reproducing", and "Learning as understanding". The relations between epistemological beliefs and conceptions about learning were further examined by structural equation modelling and path analysis, using LISREL 8.5 for Windows (Chan, unpublished data). In the study, four structural models were proposed to examine the relations with epistemological beliefs as predictors and selected pairs of quantitative and qualitative conceptions about learning as dependent variables. The four proposed models were:

M1: "Authority/Expert Knowledge", "Certainty Knowledge", "Learning Effort/Process", and "Innate/Fixed Ability" as predictors with "Learning as increase in knowledge", and "Learning as remembering and reproducing" as dependent or outcome variables (quantitative conceptions only)

M2: "Authority/Expert Knowledge", "Certainty Knowledge", "Learning Effort/Process", and "Innate/Fixed Ability" as predictors with "Learning as understanding" and "learning as a means to an end" as dependent or outcome variables (qualitative conceptions only)

M3: "Authority/Expert Knowledge", "Certainty Knowledge", "Learning Effort/Process", and "Innate/Fixed Ability'" as predictors with "Learning as increase in knowledge", and "Learning as understanding" as dependent or outcome variables (quantitative plus qualitative conceptions combination 1)



* < .05
Note:
authknow =Authority/Expert knowledge
certknow = Certainty knowledge
learnefp = Learning effort/process
innatabi = Innate/Fixed ability
lrr = Learning as remembering and reproducing
lau = Learning as understanding

Fig. 12.4 Path diagram with standardized estimates of coefficients for epistemological beliefs and quantitative plus qualitative conceptions about learning combination 2 (M4)

M4: "Authority/Expert Knowledge", "Certainty Knowledge", "Learning Effort/ Process", and "Innate/Fixed Ability" as predictors with "Learning as remembering and reproducing", and "Learning as understanding" as dependent or outcome variables (quantitative plus qualitative conceptions combination 2)

It was found that all the four models fit with data and satisfactory goodness of fit index were obtained. For model 1, RMSEA = .042, NNFI = .90, CFI = .91, GFI = .87, AGFI = .84, RMR = .07, for model 2, RMSEA = .045, NNFI = .90, CFI = .91, GFI = .86, AGFI = .83, RMR = .067, for model 3, RMSEA = .042, NNFI = .90, CFI = .91, GFI = .85, AGFI = .82, RMR = .072, and for model 4, RMSEA = .041, NNFI = .90, CFI = .91, GFI = .87, AGFI = .84, RMR = .067. The path diagrams are shown in Figs. 12.1–12.4.

In all cases, the relations are very strong as indicated by the value of the path coefficients. The conception "Learning as an increase in knowledge" probably is influenced by the conception "Learning as remembering and reproducing". Students with such quantitative conceptions are likely to adopt a rote-memory approach in learning, trying to memorize, and reproduce what they are taught in class so as to secure the conception that they have gained or increased their knowledge (Fig. 12.1).Parallel to this, students might consider "Learning as understanding" important in learning. It is only through understanding the materials they read that they can later remember and reproduce, hence ensuring an increase in knowledge in their perception (see Figs. 12.3 and 12.4). Subsequently they might adopt a deep approach in their learning. However, the strong and positive association between conceiving "Learning as understanding" and "Learning as remembering and reproducing" implies the two conceptions are not contrasting, instead it is one leading to the other. Such a relation supports that some researchers' claim that Hong Kong Chinese students are using a "deep memorization" approach or strategy in learning rather than a surface approach and rote learning (Kember, 1996; Kember & Gow, 1990; Marton et al., 1997). It should be noted that understanding is a process to gain knowledge and not the product of learning. This explains why the conception "Learning as a means to an end" has a very strong association and predictor effect on the conception "Learning as understanding" (Fig. 12.2).

12.7 Conclusion and Implications

The series of correlation study by the author with Hong Kong teacher education students in different years found significant relations between epistemological beliefs and traditional and constructivist conceptions about teaching and learning, quantitative and qualitative conceptions about learning and surface and deep learning strategies. Therefore, the author speculated a direct predictor effect of epistemological beliefs on the above variables and has confirmed the predictor effect through structural modeling and path analysis. As well, the author speculated an indirect effect of epistemological beliefs on learning strategies mediated by the conceptions of learning held by the students and this can be verified by means of structural modeling and path analysis. The studies have assisted our understanding of the relations between epistemological beliefs and these meta-cognitive variables which have not been studied in sufficient depth previously.

Arising from these studies, the author suggests that further research on the relation between epistemological beliefs and motivation such as achievement or motivational goals of students could be conducted so as to better understand how motivation including achievement or motivational goals is related to or predicted by epistemological beliefs. While it is reported in research literature that achievement or motivational goals (e.g., learning/mastery goals and performance goals) are important driving forces of learning and that achievement goals are related to deep and surface learning strategies adopted by students, it is possible that such relations may be accounted for by the interrelationships existing between epistemological beliefs, motivation goals and learning strategies. The results obtained would add new and significant knowledge in this area, not only helping teachers and educators to better understand the nature and relations between the cognitive, metacognitive and affective variables in learning, but also provide implications for promoting effective learning.

References

Arredondo, D. E., & Rucinski, T. T. (1996, Nov.). *Epistemological beliefs of Chilean educators and school reform efforts*. Paper presented at the Tercer Encuentro National de Enfoques Actuales en education Pontificia Universidad Catohea Chile Santiago de Chile. ED 402673.

Biggs, J. (1987). *Student approaches to learning and studying*. Hawthorn, Vic.: Australian Council for Educational research.

Biggs, J. B., & Moore, P. (1993). *The process of learning* (3rd edition). New York: Prentice-Hall.

Biggs, J. B., Kember, D., & Leung, Y. P. (2001). The revised two-factor study process questionnaire: R-SPQ-2F. *British Journal of Educational Psychology*, 71, 133–149.

Calderhead, J. (1996). Teachers: Beliefs and knowledge. In D. C. Berliner, & R. C. Calfee (Eds.), *Handbook of educational psychology* (pp. 709–725). New York: Macmillan.

Cano, F. (2005). Epistemological beliefs and approaches to learning: Their change through secondary school and their influence on academic performance. *British Journal of Educational Psychology*, 75(2), 203–221.

Chan, K. W. (2003). Hong Kong teacher education students' epistemological beliefs and approaches to learning. *Research in Education*, 69(1), 36–50.

Chan, K. W. (2006). The structure and nature of epistemological beliefs: Implications from literature review and syntheses of research findings. Journal of Psychology in Chinese Societies, 7(1), 141–161.

Chan, K. W. (unpublished data). *Pre-service teacher education students' epistemological beliefs and conceptions about learning*.

Chan, K. W., & Elliott, R. G. (2000). Exploratory study of epistemological beliefs of Hong Kong teacher education students: Resolving conceptual and empirical issues. *Asia Pacific Journal of Teacher Education*, 28(3), 225–234.

Chan, K. W., & Elliott, R. G. (2002). Exploratory study of Hong Kong teacher education students' epistemological beliefs – Cultural perspectives and implications on beliefs research. *Contemporary Educational Psychology*, 27(3), 392–414.

Chan, K. W., & Elliott, R. G. (2004a). Epistemological beliefs across cultures: Critique and analysis of beliefs structure studies. *Educational Psychology*, 24(2), 123–142.

Chan, K. W., & Elliott, R. G. (2004b). Relational analysis of personal epistemology and conceptions about teaching and learning. *Teaching and Teacher Education*, 20(8), 817–831.

Clarebout, G., Elen, J., Luylen, L., & Bamps, H. (2001). Assessing epistemological beliefs: Schommer's questionnaire revisited. *Educational Research and Evaluation*, 7(1), 53–77.

Ennis, C. D., Cothran, D. J., & Loftus, S. J. (1997). The influence of teachers' educational beliefs on their knowledge organization. *Journal of Research and Development in Education*, 30(2), 73–86.

Hau, K. T., & Salili, F. (1990). Examination result attribution, expectancy and achievement goals among Chinese students in Hong Kong. *Educational Studies*, 16, 17–31.

Hau, K. T., & Salili, F. (1996). Achievement goals and causal attributions of Chinese students. In S. Lau (Ed.), *Growing up the Chinese way: Chinese child and adolescent development* (pp. 121–145). Hong Kong: The Chinese University of Hong Kong Press.

Hofer, B. K. (2000). Dimensionality and disciplinary differences in personal epistemology. *Contemporary Educational Psychology*, 25(4), 378–405.

Hofer, B. K., & Pintrich, P. R. (1997). The development of epistemological theories: Beliefs about knowledge and knowing and their relation to learning. *Review of Educational Research*, 67(1), 88–140.

Hofer, B. K., & Pintrich, P. R. (Eds.). (2002). *Personal epistemology: The psychology of beliefs about knowledge and knowing*. Mahwah, NJ: Lawrence Erlbaum.

Jehng, J. C. J., Johnson, S. D., & Anderson, R. C. (1993). Schooling and students' epistemological beliefs about learning. *Contemporary Educational Psychology*, 18(1), 23–25.

Kardash, C. M., & Scholes, R. J. (1996). Effects of preexisting beliefs, epistemological beliefs, and need for cognition on interpretation of controversial issues. *Journal of Educational Psychology*, 88(2), 260–271.

Kember, D. (1996). The intention to both memorise and understand: Another approach to learning? *Higher Education* 31, 341–351.

Kember, D., & Gow, L. (1990). Cultural specificity of approaches to study. *British Journal of Educational Psychology*, 13(2), 113–125.

King, P. M. & Kitchener, K. S. (1994). *Developing reflective judgment: Understanding and promoting intellectual growth and critical thinking in adolescents and adults*. San Franscisco, CA: Jossey-Bass.

King, P. M., & Kitchener, K. S. (2002). The reflective judgment model: Twenty years of research on epistemic cognition. In B. K.Hofer & P. R. Pintrich (Eds.), *Personal epistemology. The psychology of beliefs about knowledge and knowing* (pp. 37–61). New Jersey: Lawrence Erlbaum.

Lau, S. (Ed.), (1996). *Growing up the Chinese way: Chinese child and adolescent development*. Hong Kong: The Chinese University of Hong Kong Press.

Lee, B. (1995). *Differences in the epistemological beliefs of Korean and American graduate students and their influence on an academic writing task*. Ph.D. Dissertation. The University of Texas at Austin.

Lin, C. H. (2001). Epistemological development and academic performance among elementary students. *Journal of National Taichung Teachers College*, 15, 191–206.

Marland, P. (1998). Teachers' practical theories: Implications for preservice teacher education. *Asia-Pacific Journal of Teacher Education & Development*, 1(2), 15–23.

Marton, F., Dall'Alba, G., & Beaty, E. (1993). Conceptions of learning. *International Journal of Educational Research*, 19, 277–300.

Marton, F., Watkins, D., & Tang, C. (1997). Discontinuties and continuties in the experience of learning: An Interview Study of high-school students in Hong Kong. *Learning and Instruction*, 7(1), 21–48.

Mason, L., & Boscolo, P. (2004). Role of epistemological understanding and interest in interpreting a controversy and in topic-specific belief change. *Contemporary Educational Psychology*, 29, 103–128.

Pajares, M. F. (1992). Teacher beliefs and educational research: Cleaning up a messy construct. *Review of Educational Research*, 62(3), 307–332.

Paulsen, M. B., & Feldman, K. A. (1999). Student motivation and epistemological beliefs. *New Directions for Teaching and Learning*, 78, 77–80.

Paulsen, M. B., & Gentry, J. A. (1995). Motivation, learning strategies, and academic performance: A study of the college finance classroom. *Financial Practice and Education*, 5(1), 78–89.

Paulsen, M. B., & Wells, C. T. (1998). Domain differences in the epistemological beliefs of college students. *Research in Higher Education*, 39(4), 365–384.

Perry, W. G. (1968). *Patterns of development in thought and values of students in a liberal arts college: A validation of a scheme*. Cambridge, MA: Bureau of Study: Counsel, Harvard University. (ERIC Document Reproduction Service No. ED 024315).

Purdie, N., & Hattie, J. (2002). Assessing students' conceptions of learning. *Australian Journal of Educational & Developmental Psychology*, 2, 17–32.

Qian, G., & Alvermann, D. (2000). Relationship between epistemological beliefs and conceptual change learning. *Reading Writing Quarterly*,16(1), 59–74.

Richardson, V. (1996). The role of attitudes and beliefs in learning to teach. In J. Sikula (Ed.), *Handbook of research in teacher education* (pp. 102–119). New York: Macmillan.

Ryan, M. P. (1984). Monitoring text comprehension: Individual differences in epistemological standards. *Journal of Educational Psychology*, 76, 1226–1238.

Schoenfeld, A. H. (1985). *Mathematical problem solving*. San Diego, CA: Academic Press.

Schommer, M. (1990). Effects of beliefs about the nature of knowledge on comprehension. *Journal of Educational Psychology*, 82(3), 498–504.

Schommer, M. (1993). Epistemological development and academic performance among secondary students. *Journal of Educational Psychology*, 85(3), 406–411.

Schommer, M. (1994). Synthesizing epistemological belief of research: Tentative understandings and provocative confusions. *Educational Psychology Review*, 6(4), 293–319.

Schommer, M., & Walker, K. (1995). Are epistemological beliefs similar across domains ? *Journal of Educational Psychology*, 87(3), 424–432.
Schommer, M., Crouse, A., & Rhodes, N. (1992). Epistemological beliefs and mathematical text comprehension. Believing it is simple does not make it so. *Journal of Educational Psychology*, 84, 435–443.
Schommer, M., Duell, O., & Barker, S. (2003). Epistemological beliefs across domains using Biglan's classification of academic discipline. *Research in Higher Education*, 44(3), 347–66.
Schraw, G. (2001). Current themes and future directions in epistemological research: A commentary. *Educational Psychology Review*, 13(4), 451–465.
Schraw, G., & Olafson, L. (2002). Teachers' epistemological worldviews and educational practices. *Issues in Education*, 8(2), 99–148.
Schraw, G., Bendixin, L. D., & Dunkle, M. E. (2002). Development and validation of the epistemic belief inventory (EBI). In B. K. Hofer & P. R. Pintrich (Eds.), *Personal epistemology. The psychology of beliefs about knowledge and knowing* (pp. 261–275). New Jersey: Lawrence Erlbaum.
Wood, P., & Kardash, C. (2002). Critical elements in the design and analysis of studies of epistemology. In B. K. Hofer & P. R. Pintrich (Eds.), *Personal epistemology. The psychology of beliefs about knowledge and knowing* (pp. 231–261). Mahwah, NJ: Lawrence Erlbaum.
Youn, I. (2000). The cultural specificity of epistemological beliefs about learning. *Asian Journal of Social Psychology*, 3(1), 87–105.

Chapter 13
The Use of Internet-based Instruction for the Development of Epistemological Beliefs: A Case Study in Taiwan

Chin-Chung Tsai

Abstract Researchers have proposed that to foster epistemological development, students should engage in the discussion of controversial issues, conduct open-ended inquiry projects, discuss, and analyze ill-structured problems, work on group learning, peer interactions or so-called constructivist-based instructional activities. Clearly, the Internet-based learning environments contain rich information and a variety of perspectives and viewpoints for inquiry exploration or the debates of controversial issues. They also allow numerous ways of group learning and peer interactions, either synchronous or asynchronous. The purpose of this study was to investigate a group of Taiwanese high school students' epistemological development by involving in some Internet-based inquiry learning activities in science. The students were asked to find more online information to explore scientific knowledge taught in science class further. Also, they were requested to search Internet information to resolve some controversial issues, and they were allowed some opportunities to participate in some online discussions and debates. Students' standards of evaluating online information and their epistemological beliefs toward science were probed before and after the treatment instruction by using questionnaires. Through comparing the students' responses, it was found that their judgmental standards of assessing online information became more sophisticated, and their epistemological beliefs toward science, in some aspects, were enhanced. Some of the findings were interpreted through a cultural lens. Future research issues were also discussed.

13.1 Introduction

Epistemology is the study of knowledge and knowing (Burr & Hofer, 2002; Hofer, 2001; Hofer & Pintrich, 1997). Research evidence has revealed that students' epistemological beliefs, representing their views toward the nature of knowledge and knowing, play an important role in learning beliefs, learning strategies, and learning outcomes (Buehl & Alexander, 2001; Hofer & Pintrich, 1997; Duell & Schommer, 2001). For example, research has found that students with more

National Taiwan University of Science and Technology, Taipei, Taiwan ROC

M. S. Khine (ed.), *Knowing, Knowledge and Beliefs: Epistemological Studies across Diverse Cultures.*

sophisticated or constructivist-aligned epistemological beliefs tended to have more meaningful learning strategies, better motivational approaches and task performances than those with more naïve, or dualist epistemological beliefs (e.g., Buehl & Alexander, 2005; Rodriguez & Cano, 2006; Paulsen & Feldman, 2005).

As the Internet is widely accessible to almost everyone, the usage of the Internet for instruction has been increasingly popular. Rather than using the Internet for totally online instruction, in current stage, one of the major utilizations for implementing Internet for instruction is to search online information to assist teaching and inquiry learning. As the Internet environments contain rich information with a variety of perspectives, some inquiry-oriented exploratory learning activities can be effectively conducted with the assistance of Internet resources. Hence, the present study was conducted to examine the effects of some Internet-based inquiry-oriented instructional activities on the development of students' epistemological beliefs.

The conduct of this study is mainly based on the research work of Tsai (2004a). Tsai (2004a) has proposed that educators should not only perceive the Internet as a cognitive or metacognitive tool for instruction; rather, it should be regarded as an "epistemological" tool. To use the Internet as cognitive or metacognitive tool, students are asked or encouraged to obtain information, develop knowledge and skills, reorganize knowledge, make conceptual change, build connections between new knowledge and previous experiences and to learn how to learn via Internet-based environments. Consequently, some Internet-based systems have been developed, such as those focusing on visualization, virtual reality, peer collaboration and concept mapping. However, when the Internet is perceived as an epistemological tool, learners are encouraged to elaborate the following questions in great depth:

- Which information is more important than others?
- Which information or knowledge bits are more reliable and valid than others?
- What counts for "knowledge"?
- What is the nature of their knowledge (and learning)?
- How to resolve the conflicts between various perspectives of knowledge?
- How to effectively integrate all sorts of knowledge into a coherent or viable framework?

Tsai (2004a) believes that the rich and extended online resources on the Internet provide adequate opportunities for students to explore these epistemological questions further, as they may frequently experience different or even conflicting theoretical perspectives on the Internet. In addition, the Internet-based environments contain a variety of interactions, including information, peers, experts, and decontextualized individuals (Tsai, 2001a, b). These interactions will also help learners deeply contemplate these questions.

By using the Internet as an "epistemological" tool, students should make reflective judgments in Web navigation, informative decision-making in Web contexts, and meaningful interactions with Web materials, peers, and experts. As a result, the standards of evaluating online information are quite important. Educators have proposed the idea of "conceptual ecology" to interpret a student's learning, and "epistemological commitments," that is, the standards of assessing the merit of knowledge, are regarded as one of the essential features in his/her conceptual ecology (e.g., Posner et al., 1982; Strike & Posner, 1985). In a similar rationale, Tsai (2004b) has initiated the concept of "information commitments" as a set of evaluative standards in which learners utilize to examine the accuracy and usefulness of Internet-based materials. Through interviewing two experts specialized in Web-based instruction and ten college students, Tsai (2004b) has suggested a framework categorizing the information commitments. The framework described a range of commitments from "authority" to "multiple sources" as the evaluative standards about the correctness of Web-based materials, and a range of views from "technical" (such as the ease of retrieving information or the format of online information) to "content" (the relevancy to the intended search) for the usefulness of Web-based materials. Tsai (2004b) found that the experts expressed information commitments more oriented to "multiple sources," and "content," while many of the college students held commitments more aligned with "authority" and "technical."

Figure 13.1 shows the relationships among epistemology, epistemological commitments, and information commitments. Epistemology is a relatively broad philosophy about the nature of knowledge and knowing, which guides the practice of "epistemological commitments" and "information commitments." Despite the fact that knowledge and information can not be viewed equally, it is believed that epistemological commitments and information commitments may mutually reinforce each other, as both of them are related to some judgmental standards which may share commonality. The utilization of information commitments is certainly guided by the individual's (personal) epistemology.

When using the Internet as an epistemological tool, two assertions are derived (Tsai, 2004a). The first assertion suggests that learners with different epistemological beliefs benefit differently from Internet-based instruction. In other words, the having of advanced epistemologies may be an important prerequisite for implementing Internet-based instruction. Some studies by using correlation or regression methods have shown that students with more advanced epistemological beliefs tend to more engage in Internet-based instruction (e.g., Braten & Stromso, 2006; Tsai & Chuang, 2005).

The second assertion declares that Internet-based instruction, if used properly, will change or reshape learners' epistemologies. So, it is hypothesized that developmentally

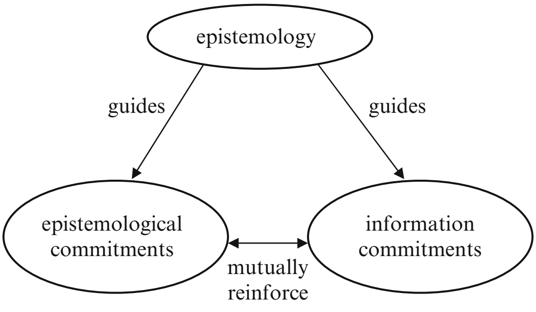


Fig. 13.1 The relationships among epistemology, epistemological commitments, and information commitments

advanced epistemological beliefs, with adequate background knowledge, can facilitate the practice of Internet-based instruction in the knowledge domain; furthermore, Internet-based instruction, with appropriate guidance and learners' self-reflections, is perceived as a (but not *the*) way to help develop advanced epistemologies. The present study, gathering research data from a group of Taiwan students, was conducted to examine the second assertion. As this study was implemented in science classes, the development particularly on students' scientific epistemological beliefs was investigated. Numerous studies in science education indicated that students possessing more constructivist-aligned epistemological beliefs about science tended to display more sophisticated learning strategies and construct more integrated knowledge structures than those with more dualist or positivist-oriented epistemological beliefs toward science (e.g., Lederman, 1992; Songer & Linn, 1991; Tsai, 1998, 1999a, 2000). Educators should facilitate science students to develop more constructivist-oriented epistemological beliefs about science. And, this study hypothesized that Internet inquiry activities could help this.

In sum, this study, based on the rationale of using the Internet as an "epistemological" tool for instruction, was undertaken to answer the following questions:

1. By using Internet-based inquiry science activities, did the participating students change their information commitments of judging online information? How?
2. By using Internet-based inquiry science activities, did the participating students change their scientific epistemological beliefs? How?

13.2 Method

13.2.1 Participants

The participants in this study included 89 10th graders (16-year-olds) in Taiwan. They were from two science classes taught by the same science teacher. The teacher had six years of teaching experiences. Among the students, 42 of them are female. All of the students had experiences of using Internet, and they had basic skills of using computers, Office software, and online search engines. In other words, they possessed adequate experiences and skills for completing the Internet learning tasks administered in this study.

13.2.2 Treatment and Context in Taiwan

Basically, the participating students were assigned some online searching tasks almost after each science class period. For example, they were asked to explore some scientific knowledge taught in science course further by finding more information on the Internet. In a few cases, the students were asked to search

Internet information to resolve some controversial issues and they also participated in some online discussions and debates. For example, this is always a fierce debate on the usage of nuclear energy for generating electric power. Then, along with the instruction for the lesson unit of nuclear energy, each student was asked to answer the following questions by searching online resources:

- What are the scientific concepts or principles related to nuclear energy?
- What is the utilization rate of using nuclear energy in total electric power in Taiwan?
- Please list the advantages and disadvantages of using nuclear energy.
- Do you support the usage of nuclear energy in Taiwan? Why?

The final question was designed for online debates. Similar online searching activities were implemented for about one month, and these students were asked to elaborate scientific knowledge through online resources, and at the same time, they were engaged in some inquiry online explorations. These activities were embedded in regular classes of science course. Students were asked to search and share some online information related to classroom instruction, but not in a very formal, structured way. In some special issues (such as the one for nuclear energy), the students had opportunities to discuss some of their searching outcomes online. In these activities, the participants were expected to explore science knowledge through the history of science, socio-scientific issues, and conflicting or competing theories in science.

Taiwan has launched an E-Learning National Program (ELNP) since January 2003, with a fund of approximately US$20 million per year. One of the major goals of ELNP is to develop e-learning for everyone. Numerous government agencies (such as Ministry of Education, National Science Council, and Department of Health) have joined this ELNP, and developed rich digital contents as well as online resources freely shared by everyone. The context of Taiwan may be highly suitable for the conduct of this study.

13.2.3 Measures

The purpose of this study was to investigate the effects of online science inquiry activities on student epistemological development. Two variables were used to represent students' epistemologies: The first variable assessed their evaluative standards of judging online information, defined previously as "information commitments." The second variable measured students' scientific epistemological beliefs. As the online learning activities were embedded in science course, students' epistemological beliefs specifically toward science were assessed.

For probing students' information commitments, the survey developed by Wu and Tsai (2005) was adopted. The survey utilized in this study included the following four scales, with a sample item provided:

- **Authority as the standard of accuracy**: assessing the extent to which students will evaluate the accuracy of online information by the "authority" of the Web sites or sources.

Item: when I view some information unknown on the Internet, I will believe in its accuracy if the information is posted in famous Web sites.

- **Multiple sources as the standard of accuracy**: measuring the extent to which students will validate the correctness of online information by relating to other Web sites, prior knowledge, peers or other printed materials.
  Item: I will try to find more Web sites to validate whether the information is correct.
- **Technical issue as the standard of usefulness:** measuring the extent to which students will judge the usefulness of online information by the ease of retrieval, the ease of searching or the ease of obtaining information. Hence, their standard for evaluating Web information is more related to some technical issues.
  Item: When I view some information on the Internet, if it is presented by animation, I will think the information is useful to me
- **Content as the standard of usefulness:** measuring the extent to which students will assess the usefulness of online information by the relevancy of its content.
  Item: When I view some information on the Internet, if its content fits my searching goal, I will think the information is useful to me.

Based on the results concluded from Tsai (2004b), the information commitments of "multiple sources," and "content" were deemed as more sophisticated standards, while the commitments more aligned with "authority" and "technical" were considered as less advanced. Each scale above included three to five items. The items were presented in 1–5 Likert scale, from "strongly disagree" to "strongly agree." The same survey was given before and after the treatment. The reliability coefficients for these scales reported in Wu and Tsai (2005) ranged from 0.74 to 0.89. The alpha coefficients calculated from the sample of this study for the scales were around 0.82, indicating satisfactory reliability of assessing students' information commitments.

To explore students' scientific epistemological beliefs, this study used the instrument developed by Tsai and Liu (2005). The instrument employed multidimensional framework for representing students' scientific epistemological beliefs, which included the following five scales with a sample item attached:

- **Invented and Creative nature of science:** assessing whether students understand that scientific reality is invented rather than discovered (the constructivist-oriented view). This scale also supports the notion that human imagination and creativity is important for the growth of scientific knowledge.
  Item: Scientists' intuition plays an important role in the development of science.
- **Theory-Laden exploration in science:** measuring the extent of agreement with the idea that scientists' personal assumptions, values, and theoretical underpinnings may affect the scientific explorations they conduct (the constructivist view). An opposite (positivist-aligned) view asserts that scientific knowledge is derived from completely objective observations and procedures.
  Item: Scientists can make totally objective observations, which are not influenced by other factors. (positivist-oriented view, scored in reverse)
- **Changing and Tentative feature of science knowledge:** exploring the extent of agreement with the assertion that scientific knowledge is changing and its

status is always tentative (constructivist-oriented view), which opposes the idea that science can offer the truths about the nature (positivist, dualist-aligned view).
Item: Contemporary scientific knowledge provides tentative explanations for natural phenomena.

- **The role of Social Negotiation in science:** assessing the agreement with the idea that the development of science relies heavily on communications and negotiations among scientists (the constructivist-oriented view). The contrary position (positivist-aligned view) indicates that science is a process of individual exploration, mainly depending on personal efforts.
  Item: The discussion, debates, and result sharing in science community is one major factor facilitating the growth of scientific knowledge.
- **Cultural impacts on science:** measuring the extent of agreement about culture-dependent nature for the development of scientific knowledge.
  Item: Scientific knowledge is the same in various cultures. (positivist-oriented view, scored in reverse)

These scales explored students' scientific epistemological beliefs in various aspects, which included the nature of knowledge (e.g., invented and creative nature of science) or knowledge justification (e.g., the role of social negotiation in science). These scales cover the issues related to the epistemology of science proposed by Ryan and Aikenhead (1992), such as the assumptions, and conceptual inventions in science, consensus making in scientific communities, and features of scientific knowledge. The instrument also placed an emphasis on the cultural impacts on the development of science (i.e., the last scale). This dimension may be particularly valuable for the science educators and students in non-Western contexts. Each scale included three to six items. All of the items above were presented in 1–5 Likert scale, while items stated in a positivist, realist, or dualist-aligned view were scored in a reverse way. Tsai and Liu (2005) reported the alpha coefficient for each scale was around 0.65–0.70. The same coefficient from the sample of this study was around 0.68 for each scale. The reliability was not very high, but it was sufficient for statistical analysis. Similarly, the same instrument for exploring students' epistemological beliefs toward science was given before and after the treatment.

13.2.4 Statistical Analysis

By two Likert-type questionnaires, this study gathered students' responses of information commitments and scientific epistemological beliefs before and after the research treatment. They were viewed as pretest and posttest for the study. A series of paired t-tests on each scale of the questionnaires were undertaken to examine students' possible epistemological development derived from the online inquiry science learning activities.

13.3 Results and Discussion

13.3.1 The Effects on Students' Information Commitments

In this study, two sets of information commitments (or standards) were employed for exploration, and for each set, two poles or orientations were used to describe their information commitments. For the standard of accuracy, one pole is "authority," while the other pole is "multiple sources." For the standard of usefulness, one pole is "technical," whereas the other pole is "content." Table 13.1 shows the results for students' scores of information commitments as assessed by the questionnaire of Wu and Tsai (2005).

Table 13.1 showed that students' scores on the scales of "multiple sources" and "content" significantly increased after the online inquiry science activities. As a result of this study, students tended to have the standards of assessing online information more oriented to "multiple sources" and "content." Based on the findings revealed by Tsai (2004b), these two poles of standards were expressed by expert Web users. Wu and Tsai (2005), by using structural equation model (SEM) analysis, also concluded that students with these two poles of standards tended to employ more sophisticated searching strategies. Therefore, the online learning activities seemed to be helpful for the students to acquire better standards of evaluating information on the Internet. These research findings also implied an epistemological development that the students might express their epistemological standards for evaluating online information more oriented to multiplicity or relativism, as called by Perry (1970). However, this interpretation should be taken with some reservation, as their scores on the scale of "authority" did not significantly decrease in the posttest. This suggested that the students might use the standard of "multiple sources" more frequently, but, in many cases, they possibly still employed the "authority" standard.

13.3.2 The Effects on Students' Scientific Epistemological Beliefs

As this study was implemented with the treatment of online inquiry learning activities particularly for science, it is important to examine how these activities may have effects on students' epistemological beliefs toward science. By using the

Table 13.1 The effects on the standards of evaluating online information

	Authority	Multiple Sources	Technical	Content
Pretest	3.66 (0.62)	3.45 (0.41)	3.85 (0.52)	3.61 (0.43)
Posttest	3.63 (0.66)	3.66 (0.55)	3.76 (0.60)	3.89 (0.63)
Paired t-value	0.40	-3.51^{**}	1.09	-3.87^{**}

instrument developed by Tsai and Liu (2005), students' scientific epistemological beliefs, both before and after the treatment, are shown in Table 13.2.

The results in Table 13.2 indicated that students' scores on the scales of "theory-laden exploration in science" and "changing and tentative feature of science knowledge" were significantly higher in posttest than those in the pretest. In other words, after the online inquiry activities, students' epistemological views toward science tended to be more philosophically constructivist; they showed more agreement with the view that science is theory-laden and its status is always tentative.

Abd-El-Khalick and Lederman (2000) proposed that there were two major approaches to changing people's epistemological beliefs toward science: one was implicit, using science-based inquiry activities, group learning, debates, and discussion of different perspectives, and the other one was explicit, utilizing elements from the history and philosophy of science. The treatment used in this study may be regarded as using the implicit approach, as the learning activities were inquiry-oriented by nature. In addition, it offered opportunities for students to explore a variety of perspectives in science and to discuss related issues either in class or online. However, the treatment may also be viewed as using the explicit approach. As the students involved in this study were often asked to explore the scientific knowledge further, they frequently found rich information about the history of science online. When evaluating students' searching outcomes for the inquiry tasks, it was frequently found that the students integrated, elaborated, or reviewed the development of scientific knowledge though a historical perspective. The research treatment may concur with both approaches to changing scientific epistemological beliefs proposed by Abd-El-Khalick and Lederman (2000). Thus, although this study was not conducted with a very structured manner of implementing the treatment lessons, students' epistemological development about science could also be observed. After this study, students had more constructivist-oriented scientific epistemological beliefs about "theory-laden exploration in science" and "changing and tentative feature of science knowledge." It is further hypothesized that the implicit approach may help students acquire more ideas about "theory-laden exploration in science," because inquiry or in-depth discussion about competing or various perspectives may facilitate students' understanding that different theories or backgrounds may yield different research outcomes in science. On the other hand, the explicit approach may help students elaborate the scientific knowledge through a historical lens; consequently, they may know more about dynamic and changing feature of science. Clearly, more research is necessary to test these hypotheses.

Table 13.2 The effects of online inquiry activities on student scientific epistemological beliefs

	Invented & Creative	Theory-laden	Changing & Tentative	Social Negotiation	Cultural impacts
Pretest	3.99 (0.67)	3.83 (0.69)	4.17 (0.63)	3.75 (0.55)	3.71 (0.78)
Posttest	4.09 (0.59)	4.03 (0.57)	4.37 (0.56)	3.82 (0.66)	3.63 (0.86)
Paired t-value	−1.59	−2.93**	−3.43**	−1.20	1.40

In addition, the results also showed that, in absolute values, the scale of "cultural impacts on science" was the only one with decreasing average scores after the treatment (though this was not statistically significant). One may caution about this result, implying that students might a little likely to express the epistemological beliefs more oriented to "culture-independence" feature about the nature of science knowledge after the online inquiry activities. These students were educated in the east, but their science was (or is) from the west. The online information about science may be mainly presented from the perspective of western science. Therefore, students might be guided to the ideology of "universal science" (but in fact, only western science) after accessing to abundant online information about science. Educators and researchers should pay attentions to this, and try to include more scientific knowledge from various cultural aspects either in teaching practices or online.

13.4 Conclusions and Future Issues

This study showed some evidence that students could have epistemological development after a series of online inquiry learning activities. For example, as a result of the study, the participating students tended to utilize the standard of judging online information more oriented to the epistemological view of "multiplicity" or "relativism" (validating information by "multiple sources"). However, when carefully reviewing students' questionnaire responses, students might still hold the standard related to the view of "dualism" or relying on "authority." This suggested that, at the conclusion of this study, the students might use the standard of "multiple sources" more frequently, but, at the same time, they probably employed the "authority" standard. Therefore, the online inquiry activities may not be quite effective to help students reduce their tendencies of using "authority" as the judgmental standard of assessing the accuracy of online information. This finding may be related to the cultural and educational context in Taiwan. In Taiwan, the teaching practice, school culture, and social image about the role of knowledge as well as the role of teacher still highlight an authoritative view about knowledge and about teaching. Therefore, students may highly adhere to the usage of "authority" as their evaluative standard of assessing information.

Moreover, as the treatment in this study was for science class, these students tended to show epistemological development especially for science; their scientific epistemological beliefs were more oriented to constructivist, and they showed more agreement with the view that scientific exploration is theory-laden and scientific knowledge is always changing. In light of these research findings, the use of the Internet as an "epistemological" tool (Tsai, 2004a) is well demonstrated in this study.

The findings derived from this study were based on students' questionnaire responses. It is suggested that future studies can carry out closer observations on student epistemological development, either in general or in science. For instance, one may argue that the probing of students' information commitments by a questionnaire may not be highly sufficient, and there may be more direct ways of understanding their information commitments. Their information commitments can be revealed by using think-aloud technique (e.g., Hofer, 2004). For example, researchers can ask the participant to reflect his/her thinking and decisions when navigating on each Web page as well as when selecting any online information. Alternatively, researchers can use screen-capture technology to record each student's search behaviors and knowledge construction processes (e.g., Bilal, 2000, 2001, 2002). Then, the student can be interviewed with the assistance of replaying the recording of screen actions. The interview can deeply explore the student's judgmental standards of evaluating each piece of online information. By this way, each student's standards of assessing online information (i.e., information commitments) can be probed in greater depth and details. Similarly, when exploring students' scientific epistemological beliefs, interview with each individual student is quite helpful to know the progression of his or her epistemological development (Tsai, 1999b).

Moreover, the treatment in this study was not conducted in a very structured way, as it was embedded in a regular science course. The online inquiry learning activities constituted just a part of instructional practice. The discussions and debates about different perspectives of scientific knowledge or socio-scientific controversial issues (e.g., the usage of nuclear energy) were not routinely implemented. Future studies are encouraged to conduct more structured instruction, and its effects on student epistemological development may be easily observed.

This study also believed the importance of argumentations and social negotiations on epistemological development. Clearly, Internet-based learning environments, either synchronous or asynchronous, allow adequate opportunities for argumentations and social negotiations with peers and experts. Researchers may conduct more studies to carefully investigate how online discussions and argumentations may play a role in student epistemological development. Finally, more research should examine how cultural factors may affect students' epistemological development.

Note and Acknowledgment A part of this paper has been presented in International Science Education Conference, held in Singapore, November 22–24, 2006. Funding of this research work is supported by National Science Council, Taiwan, under grant numbers 94-2511-S-009-003 and 95-2511-S-011-003-MY3.

References

Abd-El-Khalick, F., & Lederman, N. G. (2000). Improving science teachers' conceptions of nature of science: A critical review of the literature. *International Journal of Science Education*, 22, 665–701.

Bilal, D. (2000). Children's use of the yahooligans! web search engine: I. Cognitive, physical, and affective behaviors on fact-based search tasks. *Journal of the American Society for Information Science*, 51, 646–665.

Bilal, D. (2001). Children's use of the yahooligans! web search engine: II. Cognitive and physical behaviors on research tasks. *Journal of the American Society for Information Science*, 52, 118–136.

Bilal, D. (2002). Children's use of the yahooligans! web search engine: III. Cognitive and physical behaviors on fully self-generated search tasks. *Journal of the American Society for Information Science*, 53, 1170–1183.

Braten, I., & Stromso, H. I. (2006). Epistemological beliefs, interest, and gender as predictors of Internet-based learning activities. *Computers in Human Behavior*, 22, 1027–1042.
Buehl, M. M., & Alexander, P. A. (2001). Beliefs about academic knowledge. *Educational Psychology Review*, 13, 325–351.
Buehl, M. M., & Alexander, P. A. (2005). Motivation and performance differences in students domain-specific epistemological belief profiles. *American Journal of Educational Research*, 42, 697–726.
Burr, J. E., & Hofer, B. K. (2002). Personal epistemology and theory of mind: Deciphering young children's beliefs about knowledge and knowing. *New Ideas in Psychology*, 20, 199–224.
Duell, O. K., & Schommer, M. (2001). Measures of people's beliefs about knowledge and learning. *Educational Psychology Review*, 13, 419–449.
Hofer, B. K. (2001). Personal epistemology research: Implications for teaching and learning. *Educational Psychology Review*, 13, 353–383.
Hofer, B. K. (2004). Epistemological understanding as a metacognitive process: Thinking aloud during online searching. *Educational Psychologist*, 39, 43–55.
Hofer, B. K., & Pintrich, P. R. (1997). The development of epistemological theories: Beliefs about knowledge and knowing and their relation to learning. *Review of Educational Research*, 67, 88–140.
Lederman, N. G. (1992). Students' and teachers' conceptions of the nature of science: A review of the research. *Journal of Research in Science Teaching*, 29, 331–359.
Paulsen, M. B., & Feldman, K. A. (2005). The conditional and interaction effects of epistemological beliefs on the self-regulated learning of college students: Motivational strategies. *Research in Higher Education*, 46, 731–768.
Perry, W. G. (1970). *Forms of intellectual and ethical development in the college years: A scheme*. New York: Holt, Rinehart & Winston.
Posner, G. J., Strike, K. A., Hewson, P. W., & Gertzog, W. A. (1982). Accommodation of a scientific conception: Toward a theory of conceptual change. *Science Education*, 66, 211–227.
Rodriguez, L., & Cano, F. (2006). The epistemological beliefs, learning approaches and study orchestrations of university students. *Studies in Higher Education*, 31, 617–636.
Ryan, A. G., & Aikenhead, G. S. (1992). Students' preconceptions about the epistemology of science. *Science Education*, 76, 559–580.
Songer, N. B., & Linn, M. C. (1991). How do students' views of science influence knowledge integration? *Journal of Research in Science Teaching*, 28, 761–784.
Strike, K. A., & Posner, G. J. (1985). A conceptual change view of learning and understanding. In L. H. T. West & Pines, A. L. (Eds.), *Cognitive structures and conceptual change* (pp. 211–231). Orlando, FL: Academic Press.
Tsai, C. -C. (1998). An analysis of scientific epistemological beliefs and learning orientations of Taiwanese eighth graders. *Science Education*, 82, 473–489.
Tsai, C. -C. (1999a). "Laboratory exercises help me memorize the scientific truths": A study of eighth graders' scientific epistemological views and learning in laboratory activities. *Science Education*, 83, 654–674.
Tsai, C. -C. (1999b). The progression toward constructivist epistemological views of science: A case study of the STS instruction of Taiwanese high school female students. *International Journal of Science Education*, 21, 1201–1222.
Tsai, C. -C. (2000). Relationships between student scientific epistemological beliefs and perceptions of constructivist learning environments. *Educational Research*, 42, 193–205.
Tsai, C. -C. (2001a). The interpretation construction design model for teaching science and its applications to Internet-based instruction in Taiwan. *International Journal of Educational Development*, 21, 401–415.
Tsai, C. -C. (2001b). A review and discussion of epistemological commitments, metacognition, and critical thinking with suggestions on their enhancement in Internet-assisted chemistry classrooms. *Journal of Chemical Education*, 78, 970–974.
Tsai, C. -C. (2004a). Beyond cognitive and metacognitive tools: The use of the Internet as an "epistemological" tool for instruction. *British Journal of Educational Technology*, 35, 525–536.

Tsai, C. -C. (2004b). Information commitments in web-based learning environments. *Innovations in Education and Teaching International*, 41, 105–112.

Tsai, C. -C., & Chuang, S. -C. (2005). The correlation between epistemological beliefs and preferences toward Internet-based learning environments. *British Journal of Educational Technology*, 36, 97–100.

Tsai, C. -C., & Liu, S. -Y. (2005). Developing a multi-dimensional instrument for assessing students' epistemological views toward science. *International Journal of Science Education*, 27, 1621–1638.

Wu, Y. -T., & Tsai, C. -C. (2005). Information commitments: Evaluative standards and information searching strategies in web-based learning environments. *Journal of Computer Assisted Learning*, 21, 374–385.

Chapter 14
Assessing the Epistemological and Pedagogical Beliefs Among Pre-service Teachers in Singapore

Chai Ching Sing[1], and Myint Swe Khine[2]

Abstract In response to the challenges posed by a knowledge-based economy, Singapore has initiated a range of reforms. These reforms are essentially geared towards constructivist-oriented teaching in an ICT supported environment. Reforms in this direction usually necessitate a change in beliefs. However, studies on teachers' epistemological and pedagogical beliefs are rare in Singapore. As such, we attempted to provide an overview of the epistemological and pedagogical beliefs of Singapore pre-service teachers based on the survey data we obtained from the 2005 cohort of pre-service teachers (N = 877). The results indicate that Singaporean pre-service teachers do hold compatible epistemological and pedagogical beliefs that underlie many of the reform initiatives. However, the findings contradict with studies that reported Singapore classroom practice as predominantly teacher-centred. Contextual factors such as time constraint and an over emphasis of examination results could be the reasons why pre-service teachers teach in a manner that is consistent to their beliefs. An alternative interpretation of the contradicting results would be that there are other forms of beliefs such as teacher efficacy that may be more important in determining classroom practices.

14.1 Introduction

With the rapid pace of globalisation and the need for different manpower for knowledge-based economies, educational reforms are taking place at a fast rate in both the developed and developing nations around the world. These educational reforms call for changes not only in teaching but also the relevant beliefs that teachers hold with respect to knowledge and teaching. Since 1997, Singapore has launched a series of educational reform initiatives that aims to move its teaching force towards creating more constructivist oriented student-centred learning environments. However, the success of these reforms has been doubted despite much

[1]*Nanyang Technological University*, *Singapore*

[2]*Murdoch University, Perth*, *Australia*

M. S. Khine (ed.), *Knowing, Knowledge and Beliefs: Epistemological Studies across Diverse Cultures.*

fiscal provisions being channelled to schools (Koh, 2004). One barrier may be due to the implicit beliefs that teachers hold. Constructivist oriented teaching and learning activities require teachers to view knowledge claims as uncertain and knowing as a process of constructing personally meaningful understanding. This is different from traditional teaching, which treats knowledge as largely unproblematic verified facts to be absorbed by passive recipients. In this chapter, we investigate the epistemological and pedagogical beliefs of pre-service primary teachers (N = 877) in Singapore who are undergoing training at the National Institute of Education, Singapore. We hope that by generating a profile of the pre-service teachers' epistemological beliefs, we can gain a better understanding of their readiness to implement the ambitious form of constructivist teaching (Cohen, 1988) that underlies many of the reform initiatives. This study also provides a snapshot of the beliefs of university graduates raised in a Singapore multiracial society.

Epistemological beliefs and pedagogical beliefs are beliefs about knowledge and knowing (Hofer & Pintrich, 1997) and how knowledge and knowing should be cultivated in schools. These beliefs are key beliefs that need to be addressed for education to move forward in order to adapt to the challenges posed by a fast changing technological society. As advanced epistemological beliefs is associated positively with a range of learning outcomes (Schraw & Sinatra, 2004) and teacher is the key in cultivating sophisticated epistemological outlooks (Hofer, 2001), we surveyed the pre-service teachers to address the following research questions:

1. What are the general epistemological and pedagogical beliefs that Singapore pre-service teachers hold?
2. What are the variables among gender, ethnicity, major subject, level of programme and prior teaching experience that influence the epistemological and pedagogical beliefs among Singapore pre-service teachers?

14.2 Literature Review on Epistemological and Pedagogical Beliefs

In the last three decades, research on personal epistemology has converged into common stages of epistemological development. Hofer & Pintrich (1997) summarised the four main stages of development: dualism, multiplicity, relativism, and commitment within relativism. Generally, an individual starts from a dualistic stage of epistemological beliefs that views knowledge as either right or wrong and that knowledge is certain and is acquired through authoritative sources. As he/she advanced in years, he/she moves towards a more relativistic stance that views knowledge as uncertain. His/her sense of agency in constructing personal understanding also grows. The highest stage of development is committed relativism. At this stage, the individual is committed to certain values with the realisation that one does not have absolute proof of knowledge claims. The variables associated with the studies of epistemological developments include gender and educational level.

Departing from the developmental perspectives, Schommer (1990) proposed an alternative model of five dimensions of epistemological beliefs. These dimensions include "the structure, certainty, source of knowledge, the control and speed of knowledge acquisition" (Schommer, 1990, p. 498). Schommer argues that these dimensions of epistemological beliefs influence a range of learning outcomes. Using the Epistemological Beliefs Questionnaire (EBQ) she had developed, Schommer discovered that students who were more inclined to view knowledge as certain tended to be less open towards alternative views. Those who were inclined to believe that learning could happen quickly were less likely to assess their own understanding accurately and were more likely to simplify complex matters. Further studies using the EBQ strengthened Schommer's earlier work that naïve epistemological outlooks influenced learning in an unhelpful way (Schommer, 1993; Schommer-Aikins et al., 2000).

The EBQ was among the first measures of epistemological beliefs in a questionnaire format employing a Likert-type scale. It has inspired other researchers to develop similar instruments using the questionnaire format that enabled group testing and surveys to be conducted (e.g., see Chan & Elliott, 2004; Schraw et al., 2002). Employing these various measures of epistemological beliefs, researchers were able to document the associations between epistemological beliefs and other variables such as learning strategies, academic achievements, interpretation of text, and conceptual change (see Bråten & Strømsø, 2005; Mason & Boscolo, 2004; Qian & Alvermann, 2000; Trautwein & Lüdtke, 2006). Of these findings, there appeared a consensus among researchers that advanced epistemological beliefs promoted deep learning and higher-order thinking. Studies employing the survey method have also shown that epistemological beliefs was a significant factor that shaped students' choice of college majors (Trautwein & Lüdtke, 2006), which were associated with students' view on the certainty of knowledge and the orderliness of learning processes. The studies showed that compared to students majoring in "soft" fields of studies such as humanities and social science, college students majoring in "hard" field of studies such as natural sciences and engineering were inclined to view knowledge as more certain. They also viewed learning as an orderly process (Jehng et al., 1993).

The review thus far points out that personal epistemological beliefs affect learning in many ways. It seems clear that to promote better learning among students, teachers should nurture their student to develop advanced epistemological beliefs. However, the teachers themselves must first need to be epistemologically advanced in order that they can foster learning environments that promote epistemological developments. In the next few paragraphs, studies pertaining to teachers' epistemological beliefs and how these are connected to their pedagogical beliefs are reviewed.

Recent studies that investigated teachers' epistemological beliefs generally reveal that pre-service teachers do not differ much in epistemological development as compared to their counterparts in college. White (2000) and Brownlee (2001) found that student teachers' epistemological developments lie at the stage of multiplicity or relativism. Of the 29 teachers that Brownlee interviewed, only one was assessed to be in the dualistic stage while two out of twenty teachers that were interviewed by White were just departing the dualistic stage. The general trend is that pre-service teachers were distributed across a range of developmental stages in terms of their epistemological beliefs; with the majority of them holding relativistic epistemological outlooks (see also Richardson, 2003). In addition, it seemed uncommon for pre-service teachers to hold absolutist/dualistic epistemological beliefs.

Both White and Brownlee's studies employed interviews as the method for data collection. This explains why the sample size is less than 30. Bråten and Strømsø (2006) used the EBQ to explore the relationships between Norwegian student teachers' epistemological outlooks and their views about learning in ICT-enriched environment (N = 80). They reported that students who are inclined to believe that learning occurs quickly or not at all are also inclined to believe that they can process Internet searches quickly. These teachers may have overlooked the complexities involved in evaluating Internet-based information. Student teachers who tend to view knowledge as simple were less likely to appreciate web-based communication that facilitated knowledge negotiation. Ravindran et al., (2005) surveyed pre-service teachers' epistemological beliefs and their goals of learning (N = 101). They reported that the pre-service teachers' epistemological beliefs are associated with their cognitive engagement. The results of these studies supported other studies that found a positive relationship between pre-service teachers' epistemological beliefs and their learning process.

Studies on pedagogical beliefs generally classify teachers' pedagogical beliefs to be either in the category of knowledge transmission or knowledge construction (Calderhead, 1996; Entwistle et al., 2000; Samuelowicz & Bain, 2001). Teachers who are inclined to view teaching from a teacher-centred and content-oriented perspective are more likely to adopt the didactic teaching practice. They emphasise more on teachers' control of the flow of the lesson and expect students to adopt a passive role in learning. On the other hand, some teachers are inclined to view teaching as a process of facilitating students' effort in making sense of the phenomenon they encounter. This is usually labelled as student-centred and learning-oriented constructivist teaching. These categories of pedagogical beliefs were derived to a certain extent from the grounded theory perspectives (Samuelowicz & Bain, 2001). In reality, teachers often hold mixed beliefs since they hold varied beliefs about the purpose of teaching, ownership for knowledge organization and transformation, the role of students' prior knowledge and interest, and the value of teacher–student and student–student interaction (e.g., see van Driel et al., 2005). For the pre-service or beginning teachers, current reviews suggest that they are more likely to view teaching as an uncomplicated process of knowledge transmission (Richardson, 2003; Wideen et al., 1998). Such simplistic view of teaching may be resistant to change since it predisposes one's interpretation of prior experiences (Ertmer, 2005).

To date, the majority of studies on epistemological and pedagogical beliefs were conducted in the Western society. Bråten and Strømsø (2005) suggested that it is necessary to conduct studies in the Eastern cultural context where respect for authority is valued highly. Chan and Elliott (2004) studied the epistemological beliefs and pedagogical beliefs of 385 Hong Kong pre-service teachers. Their results indicated that majority of the pre-service teachers held relativistic epistemological outlooks and expressed beliefs that knowledge is uncertain. However, they were not inclined to see teaching as a process of constructing personal understanding. The mean score reported by participants for traditional conception of teaching (M = 2.63) was higher than their conception of constructivist teaching (M = 1.86). This provided further support that pre-service teachers are more inclined towards teacher-centred teaching. On the other hand, Sinatra and Kardash's (2004) reported that American pre-service teachers who viewed knowledge as developing and learning as meaning-making processes were also more receptive to the idea of teaching as facilitating knowledge building and beliefs revision. These conflicting findings suggest that the relationship between teachers' epistemological outlooks and their beliefs about teaching is complex. Teachers' espoused beliefs and the beliefs reflected through practice can be at odds due to contextual factors such as the school environments or social cultural setting. Despite this, it seems clear that advanced epistemological beliefs is a desirable teacher's characteristic because it is the basis for advancing constructivist teaching practices (Windschitl, 2002). This study attempts to contribute to existing research by examining the epistemological and pedagogical beliefs of pre-service teachers in Singapore. Singapore is unique in the sense that it is a bilingual society and culturally, it is where the east and the west meet. Previous papers that investigate Asian epistemological outlooks were conducted in places where the Confucius's influence is strong (Jehng et al., 1993, Taiwan; Chan & Elliott, 2004, Hong Kong; Youn, 2000, Korea). Our study is different from previous studies as the subjects of our study are young Singaporeans who have gone through education with English as their first language.

14.3 Method

For this study, we adopted Chan and Elliott's (2004) questionnaire and set up an online survey. We invited pre-service teachers attending the Postgraduate Diploma in Education (PGDE) at the National Institute of Education (NIE) to complete a survey questionnaire in July 2005 to participate in the survey. Out of the 1,244 pre-service teachers enrolled, 877 (70.5%) completed the survey. The age ranged from 22 to 45, with a mean of 26.9 years. The gender distribution was 563 females (64.2%) and 314 males (35.8%). Of those who responded to the survey, 340 (38.8%) pre-service teachers were enrolled in the Primary Programme and 537 (61.2%) in the secondary programme. In terms of major subject distribution, first degree classified as hard/soft discipline areas. The "hard" category includes the natural sciences, mathematics and engineering majors while the "soft" category includes subject such as language studies, humanities, and business studies. In the sample 460 (52.5%) had hard discipline background and the remaining 416 (47.4%) had soft discipline background. There is one missing case for this variable.

With regard to the distribution of ethnic background of the sample, an overwhelming majority were Chinese 778 (88.7%), Malays 65 (7.4%), and Indians 34 (3.9%). The Malays and Indians are slightly under represented in the sample compared to the national distribution of these ethnic groups. This is due to the fact that Singapore is strictly a meritocracy society. According to the educational statistic fact sheet, the distribution of students passing A level is about 86.7% Chinese, 5.5% Malay, 6.5% Indians, and the rest others (Ministry of Education, 2006). This distribution does not change much for the last 5 years and it determines largely the distribution of ethnicity among the postgraduate pre-service teachers.

The questionnaire is made up of three parts. The first part solicits demographic data such as gender and participants' major subject in their undergraduate studies. We also included years of formal teaching experience, if any, as a variable. Although we agree that this variable is not prevalent in the literature, it is of interest in this study because we believe that, pre-service teachers in Singapore would have undergone some form of teaching experience prior to attending teacher training. It thus presented us with an opportunity to find out the extent to which teaching experiences influences the pre-service teachers' epistemological and pedagogical beliefs. The second part of the questionnaire asks for the teachers' epistemological beliefs. The dimensions included were beliefs about Innate/Fixed Ability (IFA), Learning Effort/Process (LEP), Authority/Expert Knowledge (AEK), and Certainty of Knowledge (CK). The last part of the questionnaire deals with the teachers' pedagogical beliefs. The dimensions included were Constructivist Conception (CT) and Traditional Conception (TT) of teaching. All items employed a 5-point Likert scale (5 = strongly agree, 1 = strongly disagree). A low score indicates the possession of a more sophisticated belief in relation to the IFA, AEK, and CK. A high score in LEP, TT, and CT indicates a strong belief in these dimensions. Table 14.1 shows the dimensions of beliefs and sample items from the questionnaire.

Table 14.1 Dimensions of epistemological and pedagogical beliefs with sample items

	Dimension	Sample Item
Epistemological beliefs	Innate/fixed ability (IFA)	Some people are born good learners; others are stuck with limited abilities.
	Learning effort/process (LEP)	If a person cannot understand something within a short amount of time, he/she should keep trying.
	Authority/Expert knowledge (AEK)	I am very aware that lecturers know a lot more than I do and so I agree with what they say is important rather than rely on my own judgment.
	Certainty of knowledge (CK)	Scientific knowledge is certain and does not change
Pedagogical beliefs	Traditional conception (TT)	Learning means remembering what the teacher has taught.
	Constructivist conception (CT)	Learning means students have ample opportunities to explore, discuss, and express their ideas.

The data collected was analysed using the SPSS: PC Window Program. Descriptive statistics are used to describe the responses of the sample. Reliability analysis is used to check the reliabilities of the scales in the Singapore context. T-tests and one-way analysis of variance are conducted to see if any of the background variables have an influence on the epistemological and pedagogical beliefs. The level of significance was set at the 5% level for the purpose of comparison.

14.4 Results and Discussion

Table 14.2 reports the mean scores of the various dimensions of epistemological beliefs and pedagogical beliefs. The Cronbach alpha reliability coefficients and standard deviations for the various dimensions are also shown.

The reliability coefficients of the scales show that these scales have moderate to high internal consistency with the Singapore sample. The values are comparable to that obtained by Chan and Elliott (2004).

Based on the mean scores of the scales, it seems that the strongest belief held by the pre-service teachers is the constructivist conception of learning (M = 4.11). The result does not conform to our expectations. We are uncertain if such beliefs would be manifested in the classroom once the pre-service teachers completed their training. This is because existing studies that were conducted in the Singapore classrooms document another reality. For example, Liu et al. (2004) found that in the Singapore classrooms, “teachers’ talk” usually dominates the classroom discourse and practicing teachers were highly content-focus. In other word, teachers usually behaved in a highly didactic and teacher-centred manner during their teaching practice. There is a need to conduct a follow-up study to trace the pre-service teachers “enculturation” processes in schools. It also highlights the need to verify teacher’s espoused beliefs with the observed teaching practice. The second highest score is for learning effort and processes (M = 3.74). This is more congruent with our existing findings. Every school in Singapore holds remedial and enrichment classes throughout the year and this reflects a strong emphasis in hard work by schools. There is a strong belief that with repeated effort to master a subject the students can learn anything and achieve success in examinations.

Table 14.2 Mean scores of the dimensions with alpha reliability and SD

Dimension	Mean	Alpha reliability	Standard deviation
Innate/fixed ability (IFA) (8 items)	2.94	0.62	0.44
Learning effort/process (LEP) (11 items)	3.74	0.63	0.46
Authority/Expert Knowledge (AEK) 6 (items)	2.58	0.66	0.47
Certainty of knowledge (CK) (6 items)	2.79	0.64	0.62
Traditional conception (TT) (18 items)	2.62	0.85	0.44
Constructivist conception (CT) (12 items)	4.11	0.88	0.44

(N = 877)

The teachers were generally relativistic in their epistemological outlooks, as reflected by the mean scores for the dimensions of (AEK) Authority/Expert Knowledge (M = 2.58), and (CK) Certainty of Knowledge (M = 2.79) which are below the mid-point on a 5-point scale. Coupled with strong beliefs in CT and LEP, the profile of the pre-service teachers seems to be one that is congruent with the reform initiatives in Singapore. However, these findings need to be verified by surveys on in-service teachers (when the same pre-service teachers are posted to schools as trained teachers) in order for us to understand possible gaps between the espoused beliefs and actual practices. Contrary to expectations (based on cultural differences), the scores we had obtained in this study for the epistemological beliefs were close to what Chan and Elliott's (2004) study obtained but this was not so for the pedagogical beliefs. We envisage that this difference may be due to the recent educational reforms and cultural context in Singapore.

Among the variables we examined, level of programme (primary/secondary), gender, major subject (hard/soft), prior teaching experience and ethnicity differences were detected for pedagogical beliefs and some epistemological beliefs. The level of programme (primary/secondary) is related to the AEK and LEP epistemological beliefs. Primary pre-service teachers are more inclined to believe that the authority as a source of knowledge and in the learning effort and processes than the secondary pre-service teachers. Table 14.3 shows the scores based on level of programme.

The result also shows that female pre-service teachers are more inclined to believe in authority as a source of knowledge than the secondary pre-service teachers. They are also less inclined to view that ability is innate and fixed when compared to their male counterparts. Table 14.4 shows the scores based on gender differences.

Table 14.3 Programme level differences in epistemological and pedagogical beliefs

Dimension	Programme Level	N	Mean	SD	Item Mean Difference	t
AEK	Primary	340	2.63	.45	.09	2.67^{**}
	Secondary	537	2.54	.48		
LEP	Primary	340	3.78	.41	.08	2.30^{*}
	Secondary	537	3.70	.48		

$^{*}p < .05$, $^{**}p < .01$

Table 14.4 Gender differences in epistemological and pedagogical beliefs

Dimension	Gender	N	Mean	SD	Item Mean Difference	t
AEK	Female	563	2.62	.45	.13	3.86^{***}
	Male	314	2.49	.50		
IFA	Female	563	2.79	.43	−.10	-3.43^{***}
	Male	314	2.89	.46		

$^{***}p < .001$

Three other independent variables that we have investigated in this study are the participants' major subject at university, ethnicity, and teaching experience. Participants' major subject at university was collapsed into two categories: hard and soft. The "hard" category includes the natural sciences, mathematics, and engineering majors while the "soft" category includes subject such as language studies, humanities, and business studies (see Schommer-Aikins et al., 2003). As reflected in the scores, the teachers majoring in "hard" category are more inclined to view knowledge as certain, and ability is viewed as innate and fixed, and they tend to believe more in traditional teaching. This result is consistent with the findings reported by Paulsen and Wells (1998). The implication for teacher educators may be that if the teachers recruited were mainly from the hard fields, it is necessary to sensitize the teachers to ill-structured teaching environments where teachers need to make a lot of decisions based on imperfect knowledge about the world. Table 14.5 shows the scores based on major subject type differences.

Four hundred and seventy-seven participants indicated that they did not have formal teaching experiences while the other 400 were formally employed by schools as contract teachers between 3 months to a year to teach before they enrolled at the NIE. Our results indicate that teaching experience does influence teachers' pedagogical outlooks but not their epistemological beliefs. Pre-service teachers with teaching experience reported a higher score for traditional conception of teaching, which is significant at the 5% level. Table 14.6 shows the results of the analysis based on the scores of teaching experience differences.

These scores were obtained at the beginning of their teacher education. How these pre-service teachers may have changed in the course of their 1-year PGDE programme and subsequently during their first few years of teaching would be an area of interest for the teacher educators and further research in teachers' epistemological and pedagogical beliefs.

One-way analysis of variance was used to examine the influence of ethnicity on epistemological and pedagogical beliefs. The analysis shows that ethnicity has an influence on CK and IFA. Pos Hoc LSD test shows Malays to be different from the Chinese and the Indians. The mean difference between the Chinese and Malay is 0.25 and the mean difference between the Indian and Malay is 0.28. The differences are statistically different at the set 5% level. The Malays subscribe more to the view of certainty of knowledge as compared to the Chinese and Indians. There was no

Table 14.5 Differences between soft/hard fields of study

Dimensions	Field of study	N	Mean	SD	Item Mean Difference	t
IFA	Hard	460	2.85	.46	.06	1.96*
	Soft	416	2.79	.51		
CK	Hard	460	2.84	.62	.11	2.69**
	Soft	416	2.73	.62		
TT	Hard	460	2.66	.45	.08	2.50*
	Soft	416	2.58	.42		

**$p < .01$, *$p < .05$

Table 14.6 Teaching experience differences in epistemological and pedagogical beliefs

Dimension	Teaching experience	N	Mean	SD	Item Mean Difference	t
TT	None	477	2.59	.42	−.07	−2.15*
	Yes	400	2.66	.46		

*$p < .05$

difference between the Chinese and Indians. The Malay difference may be due to the religious–cultural influence that requires them to believe that their Holy Text is the only truth revealed and cannot be altered.

Difference is also found in the dimension of innate/fixed ability (IFA). The mean scores of the Chinese, Malays, and Indians are 2.84 (SD.42), 2.74 (SD .52), and 2.59 (SD .55) respectively. The Indians differ from the Chinese significantly. The mean difference is 0.24. The Malays do not differ from the Chinese and the Indians significantly. The Indians subscribe the lowest to the view that ability is innate and fixed. The Chinese seem to have a little more inclination to belief that ability is innate. Such view with pre-service teachers has to be addressed in the teacher education programme as it could lead to biasness towards children with low learning curve and lead to self-fulfilling prophecy. Table 14.7 summarises the influence of pre-teachers background variables on epistemological and pedagogical beliefs.

With the exception of the constructivist pedagogical conception one or more of the background variables of Singapore pre-service teachers influences all other dimensions. Pre-service teachers in the Primary programme, female pre-service teachers and pre-service teachers with some teaching experience are more inclined to believe in authority as a source of knowledge. Male pre-service teachers, pre-service teachers with majors in the hard fields and Chinese pre-service teachers tend to believe that ability is innate. Pre-service teachers with majors in the hard fields and Malay pre-service teachers subscribe more to the concept of certainty of knowledge. Hard fields have more established facts, rules, principles, and theories as compared to soft fields where knowledge is depended on many variables. This may have influenced pre-service teachers with major subjects in the hard fields to be more oriented to certainty of knowledge. This may also be the reason why hard field pre-service teachers are in favour of the traditional approach where teacher is in control of the content and delivery. It is important that teacher educators take all these variables into consideration in the design and delivery of the teacher education programme.

Pre-service teachers in the present study have scored relatively high in their belief about constructivist view of teaching and learning and none of the background variables are shown to have influence on this belief. Coupled with a relative low mean score in the traditional teaching scale seems to indicate a pattern of response with respect to the pedagogical beliefs scales. Perhaps, the strong emphasis by the Ministry of Education officials in constructivist pedagogical approaches in the media may have influenced the pre-service teachers to play to

Table 14.7 Influence of background variables on beliefs

Dimension/Variables	Programme level	Gender	Major subject	Ethnicity	Teaching experience
Innate/Fixed Ability (IFA)		X	X	X	
Learning Effort/Process (LEP)	X				
Authority/Expert Knowledge (AEK)	X	X			X
Certainty of Knowledge (CK)			X	X	
Traditional Conception (TT)			X		
Constructivist conception (CT)					

the gallery or provide politically correct response to these measures. Liu et al., (2004) found that, in the Singapore classrooms, pre-service teachers' behaved in a highly didactic and teacher-centred manner during their teaching practice. We too observed during the supervision of teaching practice that "teachers' talk" usually dominated the classroom discourse and pre-service teachers were highly content-focus. Chan and Elliott (2004) made similar observation in Hong Kong. A genuine change in belief to the constructivist approach to teaching and the transition from teaching-focus to learning-focus is a slow developmental process. Beginning teachers have to be guided in this direction by teacher educators and mentor teachers once they are in school.

14.5 Conclusion

In this chapter, we have generated a profile of the epistemological and pedagogical beliefs of pre-service teachers in Singapore. The profile of beliefs seems to be conducive for the implementation of constructivist-oriented student-centred learning environment. We agree with Sinatra and Kardash (2004) that more dynamic assessments of the teachers' epistemological and pedagogical beliefs are needed for researchers to achieve a better understanding of teachers' beliefs. Given the possible gaps between teachers' espoused beliefs and actual practice, it is necessary to conduct observation to verify teachers' self-reported data. Longitudinal studies that trace how teachers' beliefs change as they enter into the profession can also offer valuable information for teacher professional development.

Teacher educators also need to take into account the influence of background variables and pre-service teachers' experiences on their epistemological and pedagogical beliefs. An in-depth research is required to investigate which of the background variables have more profound influence on pre-service teachers' epistemological and pedagogical beliefs. Such variables need to be addressed in the teacher education programme. The changing beliefs of pre-service teachers may not be a natural process. Any developmental misalignment needs to be recognised and addressed to help guide the pre-service teacher.

References

Bråten, I., & Strømsø, H. I. (2005). The relationship between epistemological beliefs, implicit theories of intelligence, and self-regulated learning among Norwegian postsecondary students. *British Journal of Educational Psychology*, 75(4), 539–565.

Bråten, I., & Strømsø, H. I. (2006). Epistemological beliefs, interest, and gender as predictors of Internet-based learning activities. *Computers in Human Behavior*, 22(6), 1027–1042.

Brownlee, J. (2001). Knowing and learning in teacher education: A theoretical framework of core and peripheral epistemological beliefs. *Asia-Pacific Journal of Teacher Education and Development*, 4(1), 131–155.

Calderhead, J. (1996). Teachers: Beliefs and knowledge. In D. C. Berliner & R. C. Calfee (Eds.), *Handbook of educational psychology* (pp. 709–725). New York, NY: Macmillan.

Chan, K. W., & Elliott, R.G. (2004). Relational analysis of personal epistemology and conceptions about teaching and learning. *Teaching and Teacher Education*, 20(2004), 817–831.

Cohen, D. K. (1988). Teaching practice: Plus ça change. In P. W. Jackson (Ed.), *Contributing to educational change: Perspectives on research and practice*. Berkeley, CA: McCutchan.

Entwistle, N., Skinner, D., Entwistle, D., & Orr, S. (2000). Conceptions and beliefs about "good teaching": An integration of contrasting research areas. *Higher Education Research & Development*, 19(1), 5–26.

Ertmer, P. A. (2005). Teacher pedagogical beliefs: The final frontier in our quest for technology integration? *Educational Technology, Research and Development*, 53(4), 25–39.

Hofer, B. K. (2001). Personal epistemology research: Implications for learning and teaching. *Journal of Educational Psychology Review*, 13(4), 353–383.

Hofer, B. K., & Pintrich, P. R. (1997). The development of epistemological theories: Beliefs about knowledge and knowing and their relation to learning. *Review of Educational Research*, 67(1), 88–140.

Jehng, J., Johnson, S. D., & Anderson, R. C. (1993). Schooling and students' epistemological beliefs about learning. *Contemporary Educational Psychology*, 18, 23–35.

Koh, A. (2004). Singapore education in "New Times": Global/local imperatives. *Discourse: Studies in the Cultural Politics of Education*, 25(3), 335–349.

Liu, Y., Kotov, R., Rahim, R. A., & Goh, H. H. (2004). Chinese language pedagogic practice: A preliminary snapshot description of Singapore Chinese language classrooms. Retrieved 29 August 2005 from http://www.crpp.nie.edu.sg/course/view.php?id=254

Mason, L., & Boscolo, P. (2004). Role of epistemological understanding and interest in interpreting a controversy and in topic-specific belief change. *Contemporary Educational Psychology*, 29(2), 103–128.

Ministry of Education, Singapore (2002). Master plan II for IT in Education. Retrieved Jul 25, 2003, from http://www.moe.gov.sg/edumall/mp2/mp2_overview.htm

Ministry of Education, Singapore (2004). *The next chapter: Innovation and enterprise*. Singapore: MOE.

Ministry of Education, Singapore, (2006). Educational Factsheet. Singapore: MOE. Retrieved 14 January 2006 from: http://www.moe.gov.sg/esd/Factsheet%202006.pdf

Paulsen, M. B., & Wells, C. T. (1998) Domain differences in the epistemological beliefs of college students. *Research in Higher Education*, 39(4), 365–384.

Qian, G., & Alvermann, D. E. (2000). Relationship between epistemological beliefs and conceptual change learning. *Reading and Writing Quarterly*, 16, 59–74.

Ravindran, B., Greene, B. A., & DeBacker, T. K. (2005). Predicting preservice teachers' cognitive engagement with goals and epistemological beliefs. *The Journal of Educational Research*, 98 (4), 222–232.

Richardson, V. (2003). Preservice teachers' beliefs. In J. Raths & A. C. McAninch. (Eds.). *Teacher beliefs and classroom performance: The impact of teacher education* (pp. 1–22). Greenwich, Connecticut: Information Age Publishing.

Samuelowicz, K., & Bain, J. D. (2001). Revisiting academics' beliefs about teaching and learning. *Higher Education*, 41, 299–325.

Schommer, M. (1990). Effects of beliefs about the nature of knowledge on comprehension. *Journal of Educational Psychology*, 82(3), 498–504.

Schommer, M. (1993). Epistemological development and academic performance among secondary students. *Journal of Educational Psychology*, 85(3), 406–411.

Schommer-Aikins, M., Duell, O. K., & Barker, S. (2003). Epistemological beliefs across domains using Biglan's classification of academic disciplines. *Research in Higher Education*, 44(3), 347–366.

Schommer-Aikins, M., Mau, W. Brookhart, S., & Hutter, R. (2000). Understanding middle students' beliefs about knowledge and learning using a multidimensional paradigm. *The Journal of Educational Research*, 94 (2), 120–127.

Schraw, G., & Sinatra, G. M. (2004). Epistemological development and its impact on cognition in academic domains. *Contemporary Educational Psychology*, 29(2), 95–102.

Schraw, G., Bendixen, L. D., & Dunkle, M. E. (2002). Development and validation of the Epistemic Belief Inventory (EBI). In B. K. Hofer & P. R. Pintrich (Eds.), *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 261–275). Mahwah, NJ: Erlbaum.

Sinatra, G. M., & Kardash, C. (2004). Teacher candidates' epistemological beliefs, dispositions, and views on teaching as persuasion. *Contemporary Educational Psychology*, 29(4), 483–498.

Trautwein, U., & Lüdtke, O. (2006, in press). Epistemological beliefs, school achievement, and college major: A large-scale longitudinal study on the impact of certainty beliefs. *Contemporary Educational Psychology*.

van Driel, J. H., Bulte, A. M., & Verloop, N. (2005). The conceptions of chemistry teachers about teaching and learning in the context of a curriculum innovation. *International Journal of Science Education*, 27(3), 303–322.

White, B. C. (2000). Preservice teachers' epistemology viewed through perspectives on problematic classroom situations. *Journal of Education for Teaching*, 26(3), 279–305.

Wideen, M., Mayer-Smith, J., & Moon, B. (1998). A critical analysis of the research on learning to teach: Making the case for an ecological perspective on inquiry. *Review of Educational Research*, 68(2), 130–178.

Windschitl, M. (2002). Framing constructivism in practice as the negotiation of dilemmas: An analysis of the conceptual, pedagogical, cultural, and political challenges facing teachers. *Review of Educational Research*, 72(2), 131–175.

Youn, I. (2000). The cultural specificity of epistemological beliefs about learning. *Asian Journal of Social Psychology*, 3, 87–105.

Part IV
Perspectives on Domain-Specific Epistemology

Chapter 15
Applying the Theory of an Epistemological Belief System to the Investigation of Students' and Professors' Mathematical Beliefs

Marlene Schommer-Aikins

Abstracts This is an investigation of university students' beliefs about the nature of mathematical knowledge and learning. Twenty undergraduates and four mathematicians were asked to describe their beliefs using analogies and percentages. Comparisons between groups revealed that students were somewhat similar to mathematicians in beliefs about the control and speed of learning, and the source of knowledge. Students were dissimilar to mathematicians in beliefs about the structure, certainty, and justification of knowledge. Students who believed mathematical knowledge is a linear and unchanging, reported using superficial study habits.

15.1 Introduction

Investigations into students' beliefs about the nature of knowledge and learning in general, or epistemological beliefs, indicate that these beliefs relate to learning. For example the more students believe knowledge is certain, the more likely they will seek absolute answers and distort tentative information (Kardash & Scholes, 1996). The more students believe knowledge is organized as isolated bits and pieces, the more difficulty they have in understanding mathematical text (Schommer et al., 1992). And the more students believe learning is quick, the more difficulty they have in comprehending and summarizing academic texts (Schommer, 1990).

One of the earliest conceptions of epistemological beliefs comes from Perry's (1968) work with Harvard undergraduates. Through interviews and questionnaires he found that students entered college thinking hard facts are handed down by omniscient authority. By the time students reached their senior year, many of them had come to view knowledge as tentative and coming from reason as well as observation.

Wichita State University, Kansas, USA

M. S. Khine (ed.), *Knowing, Knowledge and Beliefs: Epistemological Studies across Diverse Cultures.*

15.2 Review of the Research Literature

Epistemological belief researchers since Perry's time have either followed along a similar line of inquiry (e.g., Baxter Magolda, 1992; Belenky et al., 1986; Kitchener & King, 1981; Ryan, 1984) or have examined substantially different epistemological dimensions. For example, Kitchener and King developed a theory about students' justification of knowledge, referred to as the Reflective Judgment Model. Their years of research suggest that individuals go through seven stages of development in Reflective Judgment. Initially, children believe that knowledge is simple and directly observable. No justification is needed. In the middle stages individuals believe that authority is the ultimate source of knowledge. Still later they sense uncertainty but deal with this uncertainty by assuming differing opinions are of equal value. Finally, they come to acknowledge uncertainty, but realize reason and evidence can render a degree of confidence. Furthermore, not all stances or opinions have the same degree of credibility.

Dweck and her colleagues (Dweck & Leggett, 1988) studied childrens' beliefs about the nature of intelligence, specifically the ability to learn. Their research suggests that children who believe that the ability to learn is fixed at birth will display helpless behavior when confronted with a difficult task. Whereas, children who believe the ability to learn can improve with time and experience will persist, try new strategies, and often succeed when faced with a difficult task.

Many researchers from the 1970s through 1990s studied epistemological beliefs across academic domains, in other words domain general beliefs. Yet other researchers chose to study epistemological beliefs within specific academic domains, in other words domain specific beliefs. For example, Songer and Linn (1991) examined students' epistemological beliefs of science with special focus on characterizing knowledge as either interrelated concepts or isolated bits. Wineburg (1991) has examined students' epistemological beliefs of history with special focus on students' assumption that history is either reporting the facts or interpreting the facts. Schoenfeld (1983, 1985) examined students' epistemological beliefs of mathematics with a special focus on the speed of learning as either quick or gradual.

In order to capture a more complete picture of students' personal epistemology, Schommer [name now changed to Schommer-Aikins] (1990) reconceived epistemological beliefs as a system of more-or-less independent beliefs that incorporated epistemological dimensions that had previously been examined separately. By system, it is meant there is more than one epistemological belief to consider. In her original conceptualization five dimensions were considered including, the structure (or organization) of knowledge, the stability of knowledge, the source of knowledge, the speed of learning, and the control of learning. By more-or-less independent, it is meant that an individual is not necessarily at the same level of sophistication across all the epistemological dimensions. For example, individuals may believe that knowledge is structured as highly interrelated concepts (as opposed to isolated bits), yet they may simultaneously believe the knowledge is never changing (as opposed to evolving).

Following-up on this theoretical stance, Schommer (1990) developed an epistemological questionnaire composed of statements about learning and knowledge. For example, "scientists can ultimately get to the truth" Students report their degree of agreement to these statements using a Likert scale. Factor analysis has yielded four of the five hypothesized factors: (a) Ability to learn, ranging from the ability to learned is fixed at birth to the ability to learn can be improved; (b) Structure of Knowledge, ranging from knowledge is organized as bits and pieces to knowledge is organized as interrelated concepts with multiple connections; (c) Speed of Learning, ranging from learning is quick or not-at-all to learning is gradual; and (d) Stability of Knowledge, ranging from knowledge is unchanging to knowledge is evolving. Similar factor structures have been generated with other college students (Schommer et al., 1992), with high school students (Schommer, 1993) and by other researchers, (Jehng et al., 1993; Schraw et al., 1995).

Using Schommer's conceptualization numerous links between epistemological beliefs and learning have been found. For example, in both cross-sectional and longitudinal studies, the more high school students believe in quick learning, the lower grade point average they earn (Schommer, 1994; Schommer et al., 1997). With more specific measures of learning, epistemological beliefs have been linked to comprehension and interpretation of written text in the fields of health, mathematics, psychology, physical sciences, and linguistics (Kardash & Scholes, 1996; Schommer, 1990; Schommer et al., 1992; Schommer & Walker, 1995).

Schommer further theorized that epistemological beliefs are more meaningful if they are conceived of as frequency distributions rather than continua. For example, one could assert that a student has a strong tendency toward believing knowledge is certain or knowledge is evolving. But a more accurate description could be obtained if a student's belief in the stability of knowledge was expressed in the percentage of knowledge that they believed was evolving, the percentage of knowledge that they believe never changes, and the percentage of knowledge that they believe is yet to be discovered (or constructed). The difference between the sophisticated learner and the less sophisticated learner would be the shape of the distribution. That is, the sophisticated learner would attribute a substantial portion of the distribution toward evolving knowledge. This would give them a propensity to seek change. The less sophisticated individual would attribute a substantial portion of the distribution toward unchanging knowledge. This would give them the propensity to resist change.

The idea that epistemological beliefs are multidimensional has been embraced by many researchers (e.g., Elder, 2002; De Corte et al., 2002; Hofer, 2004; Schraw et al., 2002; Wood & Kardash, 2002). The multidimensional conception and survey data gathering technique has allowed researchers to investigate epistemological beliefs in more analytical way with much larger sample sizes compared to interview or observational studies.

There are controversies surrounding the multidimensional view as well. Some researchers want to limit epistemological beliefs to purely philosophical epistemology by eliminating beliefs about learning. Some researchers believe that epistemological beliefs should be studied within a specific domain (e.g., within the content of mathematics) rather than being studied generally. Some researchers reject the notion that a survey can accurately assess epistemological beliefs. Still others are concerned that labeling ends of a continuum as naive and sophisticated is judgmental (Hofer & Pintrich, 1997).

Schommer-Aikins (2004) responded to these controversies. She explained that the inclusion of learning beliefs was a consequence of integrating epistemological belief research (e.g., Schoenfeld, 1983) that was already incorporating beliefs about the speed of learning and the ability to learn in what was called epistemological beliefs. Schommer-Aikins was willing to concede that perhaps knowledge beliefs and learning beliefs may need to be made distinct within the "system" of epistemological beliefs in order to avoid confusion. On the other hand, the study of learning beliefs appears to be closely linked to beliefs about knowledge. Studying both types of beliefs simultaneously is likely to provide a deeper understanding of learners.

The issue of domain general versus domain specific beliefs is not new. Indeed this argument goes back to research in study strategies. Are study strategies specific to a content area (domain specific) or are they applicable across a wide range of content areas (domain general) (Perkins & Salomon, 1989; Perkins & Simmons, 1988)? More recently researchers have concluded that both domain specific and domain general epistemological beliefs should be studied (e.g., Buehl et al., 2002; Schommer-Aikins, 2004; Sternberg, 1989). When these beliefs develop and how the levels of specificity interact with each other is yet to be determined (Schommer-Aikins & Duell, 2006).

Schommer-Aikins and Duell (2006) have attempted to clarify the labeling of ends of a continuum as naive versus sophisticated or immature versus mature for each belief. First, it is important to remember that the actual conceptualization of each epistemological belief dimension is that of a frequency distribution. The labeling of a continuum was a consequence of the quantitative assessment. The assumption was that the score generated from the questionnaire represented the dominant aspect of an individuals' belief. For example, if students scored high on believing knowledge is certain, it was assumed that this was their stronger belief. It would guide their thinking in the absence of any other outside influences as they interpreted information. This was confirmed in research in which students with high scores in certain knowledge misinterpreted tentative text as being absolutely certain (Kardash & Scholes, 1996).

Second, the meaning behind the labeling is important to understand (Schommer-Aikins & Duell, 2006). On one end of the continuum – the naive end, beliefs support basic level thinking (BLT). For example, students who have strong beliefs in simple, certain, knowledge, that is handed down by omniscient authority, have beliefs that will support learning that requires memorizing isolated facts. On the other end of the continuum the sophisticated end, beliefs support higher-order thinking (HOT). For example, students who have strong beliefs in complex, tentative knowledge that is derived from reason and evidence, have beliefs that support learning that requires critical thinking, synthesis, and application. The point of this clarification is that both ends of the continuum do support learning. A strong propensity toward one side supports basic everyday thinking, whereas a strong propensity toward the other side supports deeper thinking. Hence, epistemological beliefs can range from supporting everyday, routine thinking (BLT) to supporting higher-order thinking (HOT).

In the study reported in this chapter, epistemological beliefs are studied at a domain specific level of mathematics. Researchers in mathematical education have generated evidence that indicates elementary and secondary students' beliefs about the nature of mathematical knowledge and learning, or mathematical epistemological beliefs, are critical variables in learning mathematics (e.g., Carpenter et al., 1983; De Corte et al., 2002; Hofer, 2004; Franke & Carey, 1997; Garofalo, 1989; Kloosterman & Cougan, 1994; Schoenfeld, 1983). For example, after observing high school students attempting to solve problems researchers concluded that students often believe mathematical solutions should be found quickly or not-at-all and that mathematical knowledge is handed down by experts, who themselves are gifted with mathematical knowledge (Carpenter et al., 1983; Schoenfeld, 1983, 1985).

More recent studies have examined students' general epistemological beliefs, mathematical problem solving beliefs, and mathematical performance using multidimensional questionnaires. Using path analyses to study the relationship among these variables it was found that general beliefs lead to mathematical beliefs. Subsequently, mathematical beliefs lead to mathematical performance. This was true at both the elementary school level (Schommer-Aikins et al., 2005) and the college level (Schommer-Aikins & Duell, 2006). Specifically, the less students believed in quick learning (in general), the more likely they believed that mathematical knowledge is useful and time consuming. And, the more students believed mathematical knowledge is useful and time consuming, the better they were at mathematical problem solving.

Although the study of mathematical epistemological beliefs is not new, it was typically assessed with observation of students' mathematical problem solving with the researcher then inferring what students believed (e.g., Schoenfeld, 1983). In contrast the study being reported uses an interview method the directly questions students about their views of the source, stability, and structure of knowledge, as well as their beliefs about the speed and ability to learn. Furthermore, the characterization of sophisticated or HOT epistemological beliefs is based on beliefs from experts in the field of mathematics.

Interviews were conducted with university students and mathematicians in which they were asked to express their epistemological beliefs through descriptions, analogies, and assigning percentages to epistemological beliefs. Categorical analyses of verbal data and examination of frequency data allowed for an in depth study of students' mathematical epistemological beliefs. Mathematicians' beliefs served as a comparison standard to determine the level of sophistication shown among the students.

15.3 Method

15.3.1 Participants

Ten males with a mean age of 20.50 ($sd=5.26$) and 10 female undergraduates with a mean age of 20.30 ($sd=4.62$) from a Midwestern USA university were randomly selected from an introductory psychology class (required of all undergraduates in the university) to serve as student participants in this study. The majority of students were freshman ($n=16$) with the remainder being sophomores ($n=4$). Four male mathematicians served as expert participants in this study with a mean age of 43.74 ($sd=10.50$). Their experience as mathematicians ranged from new Ph.D. (who taught undergraduate mathematics courses for three years) to a full professor with 25 years of experience.

15.3.2 Interview

A semi-structured interview was conducted to assess individuals' beliefs about the nature of mathematical knowledge and learning, as well as their study habits, prior mathematical experience, and degree of enjoyment of math. The following questions served as a guide in the interview. Wording varied to make the dialogue more natural. Non-leading probes such as, "Could you tell me more?" and "What do you mean by that?" allowed participants to elaborate on their ideas without undue influence from the researcher.

I would like you to concentrate on the mathematics, like algebra, geometry, and statistics as I ask the following questions.

1. *Can you remember any mathematic courses that you have taken? What were they?* (For the mathematicians, *What made you become a mathematician?*)
2. *Did you enjoy them?*
3. *Where do you think mathematical knowledge comes from?* [Source of knowledge question]
4. *How do you know when information is true or not?* [Justification of knowledge question]
5. *To what degree do you believe experts in the field of mathematics? (Assign a percentage of time that you believe experts.)* [Degree of trust in authority question]
6. *Now I want you to think about the certainty or uncertainty of mathematical knowledge.*

Remember that this is your point of view. Assign percentages to the following categories that represent mathematical knowledge. You are free to assign 0% or 100% or anything in between. [Stability of knowledge question]

____*Percent of mathematical knowledge that is unchanging*
____*Percent of mathematical knowledge yet to be discovered*
____*Percent of mathematical knowledge that is always changing or evolving*

7. *Do most problems found in mathematic textbooks have no solutions, single solutions, multiple solutions, or both?*
8. *Describe how you would study a mathematical textbook.*
9. *Imagine that you are a psychologist. How would you describe the typical organization of information inside the mind of a* good student *in the mathematics? Use an analogy to help me understand you.* [Structure of knowledge question] (Participants were presented a set of analogies, since students occasionally did not understand what was meant by an analogy or what was meant by the structure of knowledge. They were told that they could select one (or more) of the analogies or create their own analogy. For example, Legos was one analogy with the description like the toy made of sticks and connectors, the organization can vary with many connections and many re-connections when the need arises. Puzzle was another analogy with the description always fitting pieces of knowledge together and seeing how they fit. The pieces only fit in one place. Once the pieces are together you can see the whole picture. Sorting Program was another analogy with the description "a computer program that places information into separate files, e.g., all the information about Japan goes in the Japan file, all the information about the food goes in the food file, etc.")

   A Good Student Analogy
   B Poor Student Analogy

10. *Why did you use those analogies for the good student and poor student?* (Although students were provided rationales with analogies, they were expected to present their own rationale.)
   [Structure of knowledge question continued]
11. *Some people think that the ability to learn in the mathematics is mostly inborn, that is, some people are born good learners, others are not. On the other hand, some people think that we actually learn how to learn. We can literally improve our ability to learn. What do you believe about the ability to learn?* [Ability to learn question]

   Assign percentages to the following two categories. Your are free to assign 0% or 100% or anything in between.

____*Percent of mathematical ability due to genetical predisposition.*
____*Percent of mathematical ability due to learning how to learn.*

12. *How would you describe the typical speed of learning mathematics material for the* average student*? Is it fast, slow…what?* [Speed of learning question]
   In the same manner assign percentages to the following categories.

____*The percent of mathematical knowledge learned gradually*
____*The percent of mathematical knowledge learned moderately slow (in between slow and fast)*
____*The percent of mathematical knowledge learned fast*

13. *How about a really <u>smart student</u>, how long do you think it typically take them to learn?*

In the same manner assign percentages to the following categories. [Speed of learning question]

____*The percent of knowledge learned gradually*
____*The percent of knowledge learned moderately slow (in between slow and fast)*
____*The percent of knowledge learned fast*

15.3.3 Procedure

For the student participants the interview was introduced as an investigation to help teachers learn more about students. The more teachers understand where students are "coming from" the better teachers they can be. For the expert participants the interview was introduced as an investigation to understand the view points of mathematicians. For both types of participants, it was made clear that there are no right or wrong answers. Rather, I simply wanted to know what they believed. The interview was audio taped and video taped with the permission of the participants in a room with complete privacy. Anonymity and confidentiality were assured. Participants' responses were transcribed.

15.3.4 Coding Responses to Open-Ended Questions

Responses to open-ended questions were examined for patterns of responses. Categories of responses were identified using responses from five participants. Using these categories, a coding scheme was developed for each open ended question. The coding scheme was then applied to the responses of the remaining participants. Occasionally participants' responses did not fit coding scheme. The coding system was revised to include a new category. Two people coded 20% of the data with an interrater reliability of 88%. Differences between raters were resolved through discussion.

15.4 Results and Interpretations

Since these data come from interviews, results and interpretations will be presented concurrently. An overall conclusion follows the results section.

15.4.1 Analysis of Source and Justification of Knowledge

Examining the first three questions about the source of knowledge, the justification of knowledge, and the degree of trust in mathematicians, reveals that students put much faith in authority figures. As show in Table 15.1, the source of knowledge generated three categories of response: (a) people's shared experiences, (b) experts, and (c) research. There was little variance in responses in that both experts and many of the students suggested knowledge was handed down by experts. The few students who mentioned people's shared experiences spoke in almost a denigrating way. For example, one student responded:

> [Math comes from] people, well books. People who were really old and they had too much time on their hands and thought of these silly things to do in math and so they wrote about them in books so people after them could do it and waste a lot of time. But I think it comes from a book. But I think it's mostly stuff that's been passed down from other people. I don't think it's really changing very much.

In this particular answer, the student appears to suggest that experts who are gifted (they thought of these silly things to do in math) have handed down this knowledge over the years. Furthermore, not much has changed in mathematics. Another students' response illustrates a simple, straightforward belief in experts, "[It came from] scholars. [It came from] experts, I guess."

The mathematicians' responses focused on expertise and historical roots. "Well mathematics is a cumulative process. It goes back to antiquity. We think of it starting with the ancient Greeks but actually it was before that if you look carefully. It is an accumulation of knowledge. In fact it is an intrinsic part of civilization."

Students' response to the justification of knowledge question, presented in Table 15.1, suggested that many students look at proofs as the litmus test. Yet others were content to simply accept an experts' word for evidence of the truth in mathematical statements. "In math it's pretty much a given thing. It's in the book." And another student comments, "you just do what the teachers tell you to. I think in math is one area that most of the things can be taken. It has been proven over and over again."

Mathematicians suggested some form of systematic checking of theorems or proofs. "Well you don't usually think so much about truth as you do correctness. There are times in mathematics when something is a theorem. A theorem is a logical argument given by a mathematician. Somebody has to check it. First the guy who created the proof has to check it. And then other people have to check it. And presumably if enough people read it with a critical eye, the probability that it's not correct becomes very small."

As indicated in Table 15.1, there is little disagreement among participants with regard to trusting experts. Both students and mathematicians had a high degree of faith in an expert's words.

The results from these three questions indicate the majority of students in this sample may be learning mathematics in a passive way. Although it is clear to them that proofs are part of justifying knowledge, they do not see a need to necessarily understand the proof, generate the proof, or check the proof. This university data is consistent with Schoenfeld's (1985) and Garofalo's (1989) work with high school students. They have found students assume that the all – knowing mathematics teacher will provide them with formulas and proofs. Their job as students is to memorize the formulas and accept the proofs. The danger in this thinking is that mathematical meaning or mathematical sense-making which Schoenfeld often describes (e.g., Schoenfeld, 1992) is never seen by the students as a critical aspect of mathematical learning.

Table 15.1 Frequency of response to questions about the source and justification of knowledge

	What does knowledge come from?	
Response	Student	Mathematician
People's shared experiences	3	0
Experts	17	4
Research	1	0
	How do we know when information is true or not?	
Response	Student	Mathematician
Accept it from experts	8	2
Cross check multiple sources	1	4
Proofs or research	14	4
We never really know for sure	2	0
	To what degree do you believe experts?	
Response	Student	Mathematician
45–64% of the time	1	0
65–79% of the time	2	0
80–100% of the time	17	4

Note. When participants' answers contained more than one response, the frequencies totals are higher than 20 for the students and 4 for the mathematicians.

15.4.2 Analysis of Stability of Knowledge

Asking students to describe the stability of knowledge in terms of percentages revealed that most of the students had strong beliefs in the certainty of knowledge. To capture the richness of these data two tables are presented. Table 15.2 shows the individual percentages that were assigned by students and mathematicians. Table 15.3 shows the summary statistics of means and standard deviations for each category of the stability of knowledge. The vast majority of students believed that 70% or more of mathematical knowledge is unchanging.

In contrast, the experts showed much more balanced beliefs. First no more that 50% of mathematical knowledge is considered as a unchanging. On the one hand, it suggests that the experts view mathematics as somewhat stable. Yet the remaining 50% of knowledge is open to being discovered or changed. This balance of beliefs is more obvious in Table 15.3 were the averages across categories of stability of knowledge are divided in about thirds for the experts. Students on the other hand display a disproportionately large percentage in the never changing category.

Studies of epistemological beliefs in general suggest that strong beliefs in the certainty of knowledge lead students to interpret tentative information as if it were absolute (Kardash & Scholes, 1996; Schommer, 1990). In the case of mathematics it may contribute to students' passivity in learning. That is, if students believe mathematics is unchanging knowledge handed down by authorities, then their reliance on authority is given legitimacy. For the truths that are handed down by authority will never change.

Table 15.2 Responses to what percentage of mathematical knowledge will never change?

	Participants	
Response (%)	Student	Mathematician
20	0	1
25	0	1
33	1	0
40	2	0
50	0	2
60	1	0
70	1	0
75	1	0
79	1	0
80	4	0
85	1	0
90	3	0
95	1	0
98	1	0
99	3	0

Table 15.3 Mean of percentages assigned to the stability of knowledge with standard deviations shown in parentheses

	Participants	
Category of Stability	Students	Mathematicians
Never changes	78.10 (20.29)	36.25 (16.01)
Yet to be discovered	14.60 (13.68)	32.50 (23.63)
Always changing	7.25 (8.71)	31.25 (13.15)

15.4.3 Analysis of the Structure of Knowledge

Students' depiction of the structure of knowledge is revealed in Tables 15.4 and 15.5. Analogies either selected or generated by the students varied widely. Two critical aspects of the analogies were considered in this analysis. Does the analogy indicate a belief that knowledge is has many complex links or does it suggest isolated bits or a linear chain of links? Does the analogy suggest the links among ideas are either flexible or rigid. The theoretical assumption is that more sophisticated (HOT) beliefs will be expressed in analogies with complex and flexible links.

The most informative aspect of these questions were students' explanations as to why they chose a particular analogy. The majority of students thought that a good mathematical learner's knowledge is either linear or rigid in its connections. Connections were considered important, but the nature of these connections was a critical issue. For some students having too many connections was a bad thing. Keep it simple was their motto. Students' portrayal of the poor mathematical learner again highlights the connections, either there were not enough connections,

Table 15.4 Frequencies of responses to questions about the organization of knowledge in the mind of a good learner

Organization of Knowledge in the Mind of a Good Learner		
Analogy	Students	Mathematicians
Railroad cars	6	0
Basket of fruit	1	0
Tidy desk	3	0
Filing cabinet	2	0
Puzzle	1	1
Legos	4	3
Spider web	2	0
Word processor	1	0
Why the Analogy Was Used to Describe the Good Leaner		
Reason	Students	Mathematicians
Fewer connections mean less confusion	2	0
Linear structure	9	0
Puzzle that fits one way	4	0
Puzzle that fits multiple ways	1	2
Highly complex and interwoven order	3	2
Information is easy to access	1	0

Table 15.5 Frequencies of responses to questions about the organization of knowledge in the mind of a poor learner

Organization of Knowledge in the Mind of a Poor Learner		
Analogy	Students	Mathematicians
Railroad cars	0	3
Basket of fruit	6	1
Filing cabinet	2	0
Puzzle	3	0
Legos	2	0
Spider web	2	0
Word processor	3	0
Faint picture	1	0
Assorted box of chocolates	1	0
Why the Analogy was Used to Describe the Poor Learner		
Reason	Students	Mathematicians
Not enough connections	7	1
Linear structure	0	3
Puzzle that fits one way	1	0
Information hard to access	0	0
Important information missing	2	0
Sloppy connections	1	0
Puzzle that fits too many ways	1	0
Too complex and interwoven	8	0

or too many connections, or for some inexplicable reason connections did not help the student access the information.

For example, one student selected the Legos for the good student and the sorting program for the poor student. "Legos for the good learner. Because it [the explanation provided in the research materials] says 'reorder.' Organizing with various connections and being able to change other pieces around to make it fit. Because people in math can bust numbers or whatever and figure out stuff, I think."

The student explains his analogy for the poor student. "Sorting program for a poor learner. Because it's just one track."

In contrast another student selects the puzzle that fits one way, for the good student and the Legos for the poor student. "To me it's the puzzle. Once you get one step and then another step and another, then it all falls into place. And it doesn't change.

Now the student explains his analogy for the poor student. Organization for the poor [learner], well it's the Legos. Cause math doesn't vary much. There are not many different connections to a problem. You know, it seems like once you do a problem, that's it. There's a certain way to do it. And it gets done that way. You can't reconnect it or you know. It's just basic."

Winne (1995), as well as other researchers (Schommer, 1994), has described a model for self regulated learning in which he portrays epistemological beliefs as the guides for the default choice of study strategies. For example, if a student believes knowledge is organized as bits and pieces, their standard of what it means to know may mean being able to recite a list of facts. This goal of learning would lead the student to select memorizing as the chief means of studying. This sequence of events could result in an impoverished mental representation and the inability of the student to apply the knowledge.

Although there is only a paucity of research to support Winne's model, there is some evidence to suggest that students who believe knowledge is organized as linear and/or isolated bits will have difficulty learning complex material. For example, Schommer et al. (1992) found that the more university students believed knowledge is organized as isolated bits and pieces, the more difficulty they had in understanding statistical text and the more likely they were to report using simple study strategies, such as memorizing, as their general study technique. It may be that the belief in the organization of knowledge leads students to the idea that "mathematical thinking consists of being able to learn, remember, and apply facts, rules, formulas, and procedures" (Garofalo, 1989, p. 503).

15.4.4 Analysis of the Control and Speed of Learning

Tables 15.6 and 15.7 reveal that students' views about the control and speed of learning tend to be more balanced and somewhat consistent with mathematicians. For the most part participants believed that much of learning is due to abilities that are acquired and that learning takes time. Nevertheless, the mathematicians in this study presented a more balanced view in their beliefs about the speed of learning. They attributed about one third of the percentages to each of the speed categories

Table 15.6 Mean of percentages assigned the ability to learn with standard deviation shown in parentheses

	Participants	
Belief About Control of Learning	Students	Mathematicians
Due to genetic predisposition	38.15 (31.54)	28.75 (24.62)
Due to learning process	61.85 (31.54)	71.25 (24.62)

Table 15.7 Mean percentages assigned to knowledge that is learned at various speeds with standard deviation in parentheses

	Percentages Assigned for the Average Learner	
Level of Speed of Learning	Students	Mathematicians
Gradual learning	44.65% (23.69)	36.25% (18.88)
Moderately slow learning	32.15% (21.30)	31.25% (10.31)
Fast learning	23.15% (20.26)	32.50% (18.93)
	Percentages Assigned for the Smart Learnerj	
Level of Speed of Learning	Students	Mathematicians
Gradual learning	27.25% (18.46)	25.00% (12.91)
Moderately slow learning	17.75% (18.03)	28.75% (13.15)
Fast learning	55.00% (25.29)	43.75% (14.93)

of the average learner and less that 50% to fast learning for smart learners. This suggests that mathematicians are more likely to believe that even smart students will need to take their time in their mathematical studies.

The university students' beliefs about the speed of learning appear to be somewhat more sophisticated compared to Schoenfeld's high school students. His work suggests that many high school students believe a mathematical problems should be solved in only a few minutes. These differences in findings may be due to the fact that the university students are older, or their work at the university is beginning to change their beliefs, or perhaps even more likely, students who have more sophisticated beliefs about the speed of learning have chosen to attend a university. More research is needed to support a more precise explanation.

The fact that these students were at least similar to mathematicians indicates that part of students' epistemological picture is positive. Dweck's work (Dweck & Leggett, 1988) suggests that the more students believe learning can be acquired, the more likely they will persist on difficult tasks. And Schommer's work (Schommer, 1990, 1993; Schommer et al., 1992) indicates that the less students believe in quick learning, the more likely they are excel in reading comprehension, and the more likely they are to earn high grade point averages.

These optimistic data about beliefs about the speed and control of learning notwithstanding, the implications for students' beliefs about the nature of knowledge, per se, that is beliefs about the structure and certainty of knowledge, is less optimistic. Students may work persistently on their mathematics. Yet, if their goal in learning is to search for oversimplified, unchanging answers, their hours of work will have limited value.

15.4.5 Analyses of Study Habits

Analyses of students' description of how they study a mathematics textbook lends support for this concern. Table 15.8 displays the categories of responses that were given to participants' self-described study habits. Fifteen out the 20 student participants described reading strategies that were weak to non-existent. One student simply said, "I don't study, I cram. And if necessary, I cheat." Others described their frustration with any initial attempt to read a mathematics book, which led them to rely on looking at examples or ask the instructor. One student describes his study habits.

Student: I usually open it up and read it and then close it right away. That's something. I don't like to read math textbooks because, I like to get the idea in class. Cause if I read it in the textbook, it's, you'll run into something you don't understand. You know, you don't understand the next step. How I usually do it is I'll do a problem, I'll do some problems, you know or just do a problem, go back to the examples, look through, and kind of try and find a problem like that. You know, and in cases, there's not always a problem like that in the examples. So.

Researcher: "Do you read the text?"

Student: "Not usually. Cause I usually get that from class if I'm paying attention."

And another student again describes the limits she will take in reading text. You can also hear the limits in her views about the ability to learn.

Student: I would look over notes and see what the teacher's gone over and I'd take one problem out of the book and do it and that would be studying. That might take me 20 minutes because it's boring. I kind of see math as either you know it or you don't. I mean, I guess you can learn it, but like you know either you caught on when they were teaching it in class if you don't understand it, you've either asked questions and learned it or you don't understand it and I don't think it's some

Table 15.8 Frequency of responses to the question, "How do you study a mathematics textbook?"

	Participants	
Study Description	Students	Mathematicians
I don't study. I cram.	1	0
I scan the bold print and examples.	14	0
I scan headings, bold, examples, then read	1	0
I read summaries first, then read the whole chapter	4	4

> thing you can really teach yourself. I don't think you can teach yourself. I can't teach myself.

In sharp contrast there are the handful of students who seem to study their mathematics book intensely. One student describes his reading process.

Student: I read everything in the chapters in math. I read everything. And I'll go back and highlight theorems that the problems I'll be dealing with. And then I do the problems. And most of the time, there's examples but I don't highlight the examples. I just, I use the examples to help with the problems.

This students' comments are similar to that of the mathematicians. Mathematicians, who were asked to describe how they studied professional articles, gave answers that contained two consistent key elements. They were careful to select material they needed, so they would not waste time. Once they determined what they needed to study, they did so with great intensity.

Mathematician: If you are talking about something like a research monograph, like something written for a graduate student, like a thesis, and it's something that I don't know about – not my expertise, then I would first look the whole thing over. Then I'd read the introduction. And I would think were the whole thing is going. And then I might pick a part of it and study that part carefully and work out all the details. And frequently the way it works is I may not read the whole thing. Not because I'm not interested, but you know there is a finite amount of time and energy. And probably the reason your reading is not for recreation, it is because you want to know something and maybe use it in research. You work out all the details. You grind it up and spit it out over and over again.

Deeper analyses of study habits and attitudes about textbooks reveal additional critical issues. When participants were asked if textbooks have single or multiple solutions, nine out of the 20 students said textbooks contained single solutions. The remainder of the students said textbooks have both single and multiple solutions. Three out of the four mathematicians said the books for early undergraduates had single answers. Problems with multiple solutions did not come up until higher-level courses were taken. The researcher asked the mathematicians, "If textbooks have single answers, then tell me, in the broader sense of mathematics, how many solutions are there typically." All the mathematicians said there were multiple solutions. One mathematician remarked, that it would be unwise to have multiple solutions in books because it would be too difficult to teach. At issue here are the attitudes of the mathematicians. None of them seem concerned by single solutions in the textbooks, even though they thought in the broader sense, that multiple solutions was more realistic. The new Ph.D. was the only mathematician who suggested that there were multiple solutions to textbooks overall, probably because he was thinking about his own text reading of higher-level mathematics.

In order to determine if there was a relationship between participants' epistemological beliefs and their study habits, three statistical analyses were carried out. First the relationship between participants' study habits and their beliefs in the organization of knowledge was tested. Study habits of simply glancing at the examples and cramming were categorized as shallow study habits. The remaining study habits were categorized as deep study habits. Rationales for the analogy of the good learner were classified as simple knowledge structure, if they suggested knowledge was organized in a linear or fixed sequence. The remainder rationales were classified as complex knowledge structure. Significant Chi Square analyses revealed that participants who believed in simple knowledge structure were likely to report shallow study habits ($n=13$), whereas those who believed in complex knowledge structure reported deeper study habits ($n=7$): χ^2 (1, $N=24$) $=9.97$, $p<.01$.

The relationship between study habits and the number of solutions found in textbooks were analyzed in a similar manner. Chi Square analyses revealed that participants who believe that textbook problems only have single solutions were likely to report shallow study habits ($n=9$) and participants believing textbooks have at least some multiple answers were more likely to report deep study habits ($n=6$): χ^2 (1, $N=24$) $=5.53$, $p<.05$.

In order to determine if there was a relationship between study habits (deep versus shallow) and participants' frequency responses, a mulitvariate analysis of variance (MANOVA) was conducted. The dependent variables were participants' frequency responses, the percent of slow learning for the average learner, the percent of slow learning for the smart student, the percent of knowledge that never changes, the percent of knowledge that is always changing, and percent of the ability to learn that is acquired. The overall multivariate analysis was significant, Wilk's Lambda F (5, 18) $=3.04$, $p<.05$, $\eta^2=.46$. Follow-up univariate analyses generated significant differences for two dependent variables, percent of knowledge that never changes F (13.37, $p<.001$, $\eta^2=.38$ and percent of knowledge that is always changing F (5, 18) $=6.06$, $p<.05$, $\eta^2=.22$. Participants who described deep study habits ascribed higher percentages to knowledge that changes (0 = 18.89% for deep studiers and 0 = 6.67% for shallow studiers) and ascribed smaller percentages to knowledge that never changes (0 = 51.67% for deep studiers and 0 = 82.80% for shallow studiers).

These results have important implications for the mathematics classroom. First, the links between participants' beliefs about the organization of knowledge and their study habits provides support for the hypothesis that epistemological beliefs guide study strategy selection (Schommer, 1994; Winne, 1995). Perhaps what is even more intriguing is the implication of students who believe that textbooks only have single answers also tend to report shallow study habits.

At issue is the nature of mathematical textbooks. For many students mathematical textbooks are signaling to them that there are single, simple answers. In addition, students' descriptions of their struggle to understand and maintain interest in the textbook, suggest that mathematical textbooks could be written more clearly and interestingly. It is as if the author of textbooks must come to realize that many students are not initially intrigued by mathematical issues. Furthermore, it is possible that some students will put forth the effort to learn, if the textbook is written in a clearer, more explicit way. In other words, mathematicians who write textbooks, need to take the perspective of a nonmathematician in order to make a link with their readers. Careful writing which nurtures epistemological beliefs may serve as a bridge between the world of mathematicians and the world of the non-mathematicians.

15.5 Conclusion

This research provides unique insight into students' epistemological beliefs by using an interview that is based on the epistemological belief system conception (Schommer, 1994). Five epistemological dimensions were examined. By comparing the level of sophistication between epistemological beliefs in a group, it is apparent that students' epistemological beliefs do not develop in synchrony. That is, in general students seemed similar to mathematicians in their beliefs about learning. On the other hand, they were not as sophisticated compared to mathematicians in their beliefs about the structure and stability of knowledge. This is important to know for the development of a theory of mathematical beliefs. It is also important for mathematics teachers to know as well. Specifically, it suggests that if students are sophisticated in some beliefs, it cannot be assumed they are sophisticated in all their beliefs.

This direct interview approach allowed students (and mathematicians) to express their epistemological beliefs with greater clarity. Analogies allowed students to describe the mental structure of mathematical knowledge with a rationale as to why the structure was helpful or harmful for the learner. For some students, mathematics is structured as a rigid, linear sequence of procedures. These students would assert that to "play around" with the order, is to invite confusion. This is in contrast to students who appreciated the complexity of mathematical knowledge.

Frequency data, particularly, for the stability of knowledge indicated that many students believe mathematical knowledge is never evolving. It is likely that these students would have even stronger reason to avoid tinkering with new ways to find solutions. The follow-up analysis that indicated believers in certain knowledge were likely to engage in shallow study habits supports this notion. All this is to say that students' beliefs about the nature of knowledge may be leading them in the opposite direction of mathematicians. Schoenfeld cites Polya in this description of playfulness.

> To a mathematician, who is active in research, mathematics may appear sometimes as a guessing game; you have to guess a mathematical theorem before you prove it, you have to guess the idea of the proof before you carry through all the details…. In science as in everyday life, when faced with a new situation, we start out with some guess…. The layman does not find it surprising to hear that the naturalist is guessing like himself. It may appear a little more surprising to the layman that the mathematician is also guessing…. If the learning of mathematics has anything to do with the discovery of mathematics, the student must be given some opportunities to do problems in which he first guesses and then proves some mathematical fact on an appropriate level. (cited in Schoenfeld, 1992, p. 339)

Although not all students will become mathematicians, it would seem critical that students develop a sense of mathematical thinking that will serve them well in day-to-day life. The mathematical epistemological beliefs held by many of these university students would not let them feel comfortable to guess and go. Rather, they seek to hold onto a rope of formulas that are written like commandments, never to be changed.

The study of epistemological beliefs is considered important to mathematics educators. Instructors can benefit from developing a deeper understanding of students' mathematical epistemological beliefs (e.g., Carpenter & Fennema, 1992; Fennema et al., 1993; Franke & Carey, 1997; Schoenfeld, 1992). For example, if teachers are taught how children think mathematically, they will subsequently modify their instruction to support students to become actively engaged in mathematic sense-making. Students' ultimately increase their conceptual understanding without detrimental effects to their computational skills (Fennema et al., 1996). In short, the more students' epistemological beliefs are understood, the more likely teachers will be prepared to understand and instruct their students.

Future research needs to address additional questions. For example, how do epistemological beliefs within a belief system affect each other? Going beyond the simple analysis of a single belief affecting a single aspect of learning, how does the interplay of epistemological beliefs affect learning? How do mathematical textbooks influence students' epistemological beliefs?

It is important that mathematical educators be aware of the students' beliefs about nature of mathematics. When students perform poorly in the classroom, the problem may greater than the lack of factual knowledge. Rather, the students' misunderstandings could be coming from tacit, yet powerful mathematical epistemological beliefs. Furthermore, explicitly including epistemological belief instruction in the curriculum may be more than a form of enrichment in the classroom. As we continue to understand the influence of epistemological beliefs, we may realize epistemological beliefs are a necessary part of instruction.

References

Baxter Magolda, M. B. (1992). Students' epistemologies and academic experiences: Implications for pedagogy. *Review of Higher Education*, 15, 265–287.

Belenky, M. F., Clinchy, B. M., Goldberger, & Tarule. (1986/1997). *Women's ways of knowing*. New York: Basic Books.

Buehl, M. M., Alexander, P. A., & Murphy. (2002). Beliefs about schooled knowledge: Domain specific or domain general? *Contemporary Educational Psychology*, 27, 415–449.

Carpenter, T. P., & Fennema, E. (1992). Cognitively guided instruction: Building on the knowledge of students and teachers. *International Journal of Educational Research*, 17, 457–470.

Carpenter, T. P., Lindquist, M. M., Matthews, W., & Silver, E. A. (1983). Results of the third NAEP mathematics assessment: Secondary school. *Mathematics Teacher*, 76, 652–659.

De Corte, E., Op't Eynde, P., & Verschaffel, L. (2002). "Knowing what to believe": the relevance of students' mathematical beliefs for mathematics education. In B. K. Hofer & P. R. Pintrich (Eds.), *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 297–320). Mahwah, NJ: Lawrence Erlbaum.

Dweck, C. S., & Leggett, E. L. (1988). A social-cognitive approach to motivation and personality. *Psychological Review*, 95, 256–273.

Elder, A. D. (2002). Characterizing fifth grade students' epistemological beliefs in science. In B. K. Hofer & P. R. Pintrich (Eds.) *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 347–363). Mahwah, NJ: Lawrence Erlbaum.

Fennema, E., Carpenter, T. L., Franke, M. L., Levi, L., Jacobs, V. R., & Empson, S. B. (1996). A longitudinal study of learning to use childrens' thinking in mathematics instruction. *Journal for Research in Mathematics Education*, 27, 403–434.

Fennema, E., Franke, M. L., Carpenter, T. P., & Carey, D. A. (1993). Using children's knowledge in instruction. *American Educational Research Journal*, 30, 555–583.

Franke, M. L., & Carey, D. A. (1997). Young children's perceptions of mathematics in problem-solving environments. *Journal for Research in Mathematics Education*, 28, 8–25.

Garofalo, J. (1989). Beliefs and their influence on mathematical performance. *Mathematics Teacher*, 82, 502–505.

Hofer, B. K. (2004). Epistemological understanding as a metacognitive process: Thinking aloud during online searching. *Educational Psychologist*, 39, 43–55.

Hofer, B., & Pintrich, P. (1997). The development of epistemological theories: Beliefs about knowledge and knowing and their relation to learning. *Review of Educational Research*, 67, 88–140.

Jehng, J. J., Johnson, S. D., & Anderson, R. C. (1993). Schooling and students' epistemological beliefs. *Contemporary Educational Psychology*, 18, 23–35.

Kardash, C. M., & Scholes, R. J. (1996). Effects of preexisting beliefs, epistemological beliefs, and need for cognition on interpretation of controversial issues. *Journal of Educational Psychology*, 88, 260–271.

Kitchener, K. S., & King, P. M. (1981). Reflective judgment: Concepts of justification and their relationship to age and education. *Journal of Applied Developmental Psychology*, 2, 89–116.

Kloosterman, P., & Cougan, M. C. (1994). Students' beliefs about learning school mathematics. *Elementary School Journal*, 94, 375–388.

Perkins, D. N., & G. Salomon (1989). Are cognitive skills context-bound? *Educational Researcher*, 18, 16–25.

Perkins, D. N., & R. Simmons (1988). Patterns of misunderstanding: An integrative model for science, math, and programming. *Review of Educational Research*, 58, 303–326.

Perry, W. G., Jr. (1968). *Patterns of development in thought and values of students in a liberal arts college: A validation of a scheme*. Cambridge, MA: Bureau of Study Counsel, Harvard University. (ERIC Document Reproduction Service No. ED 024315).

Ryan, M. P. (1984). Monitoring text comprehension: Individual differences in epistemological standards. *Journal of Educational Psychology*, 76, 248–258.

Schoenfeld, A. H. (1983). Beyond the purely cognitive: Beliefs systems, social cognitions, and metacognitions as driving forces in intellectual performance. *Cognitive Science*, 7, 329–363.

Schoenfeld, A. H. (1985). *Mathematics problem solving*. San Diego, CA: Academic Press.

Schoenfeld, A. H. (1992). Learning to think mathematically: Problem solving, metacognition, and sense making. In D. A. Gouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 334–370). New York: Macmillan.

Schommer, M. (1990). Effects of beliefs about the nature of knowledge on comprehension. *Journal of Educational Psychology*, 82, 498–504.

Schommer, M. (1993). Epistemological development and academic performance among secondary students. *Journal of Educational Psychology*, 85, 406–411.

Schommer, M. (1994). An emerging conceptualization of epistemological beliefs and their role in learning. In R. Garner & P. Alexander (Eds.), *Beliefs about text and about text instruction* (pp. 25–39). Hillsdale, NJ: Lawrence Erlbaum.

Schommer, M., & Walker, K. (1995). Are epistemological beliefs similar across domains? *Journal of Educational Psychology*, 87, 424–432.

Schommer, M., Calvert, C., Gariglietti, G., & Bajaj, A. (1997). The development of epistemological beliefs among secondary students: A longitudinal study. *Journal of Educational Psychology*, 89, 37–40.

Schommer, M., Crouse, A., & Rhodes, N. (1992). Epistemological beliefs and mathematical text comprehension: Believing it's simple doesn't make it so. *Journal of Educational Psychology*, 84, 435–443.

Schommer-Aikins, M. (2004). Explaining the epistemological belief system: Introducing the embedded systemic model and coordinated research approach. *Educational Psychologist*, 39, 19–29.

Schommer-Aikins, M., & Duell, O. K. (2006). *General and mathematical epistemological beliefs*. Paper presented at the American Educational Research Association, San Francisco.

Schommer-Aikins, M., Duell, O. K., & Hutter, R. (2005). Epistemological beliefs, mathematical problem-solving, and academic performance of middle school students. *The Elementary School Journal*, 105(3), 289–304.

Schraw, G., Bendixen, L. D., & Dunkle, M. E. (2002). Development and validation of the epistemic belief inventory (EBI). In B. K. Hofer & P. R. Pintrich (Eds.) *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 261–275). Mahwah, NJ: Lawrence Erlbaum.

Schraw, G., Dunkle, M. E., & Bendixen, L. D. (1995). Cognitive processes in well-defined and ill-defined problem solving. *Applied Cognitive Psychology*, 9, 523–538.

Songer, N. B., & Linn, M. C. (1991). How do students' views of science influence knowledge integration? *Journal of Research in Science Teaching*, 28, 761–764.

Sternberg, R. J. (1989). Domain-generality versus domain specificity: The life and impending death of a false dichotomy. *Merill-Palmer Quarterly*, 35(1), 115–130.

Wineburg, S. S. (1991). On reading of historical texts: Notes on the breach between school and academy. *American Educational Research Journal*, 28, 495–519.

Winne, P. H. (1995). Inherent details in self-regulated learning. *Educational Psychologist*, 30, 173–187.

Wood, P., & C. Kardash (2002). Critical elements in the design and analysis of studies of epistemology. In B. K. Hofer & P. R. Pintrich (Eds.) *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 231–261). Mahwah, NJ: Lawrence Erlbaum.

Chapter 16
Individual Domain-Specific Epistemologies: Implications for Educational Practice

Betsy Palmer and Rose M. Marra

Abstract This chapter will examine the implications for educational practice at the tertiary level of a theory of domain-specific epistemological development at the individual level. Educational researchers and theorists have described how the epistemological belief systems of university-level students may support or impede student learning (Jonassen et al., 2004; Moore, 1994; Wineburg, 1991, Valanides & Angeli, 2005). In previous work, the authors of this chapter have explored how individual students describe discipline specific epistemologies and how these epistemologies may be incongruent from one knowledge domain to another (Marra & Palmer, 2005; Palmer & Marra, 2004). While these incongruities have a theoretical and conceptual significance in terms of prior understandings of domain-specific epistemologies, they also offer educators a unique opportunity to challenge students' epistemological stances. We explore how university educators may specifically target the imbalance of the individual student's domain epistemologies as a "teachable moment" through inter and cross disciplinary pedagogies that leverage domain-specific epistemologies. We also discuss via empirical data, the ways in which students describe the teaching processes used in the classroom as a potential constriction on the development of more complex epistemological perspectives. We conclude with a synthesis of how individual epistemologies and instruction are intertwined and apply these concepts to university education globally.

16.1 Introduction

Personal epistemology, or the beliefs any given individual holds regarding the nature of knowledge and the process of knowing, is foundational to their educational experiences (Hofer, 2002; Hofer & Pintrich, 1997). Beginning with William Perry's (1970) work on intellectual development, a variety of theories have been developed and tested, which explicate a complex set of ideas about knowledge and knowing.

[1]*Montana State University, Bozeman*, *USA*

[2]*University of Missouri, Columbia*, *USA*

M. S. Khine (ed.), *Knowing, Knowledge and Beliefs: Epistemological Studies across Diverse Cultures.*

These theories examine the individual's beliefs about the complexity and certainty of knowledge, the process of knowing, and the sources and justification of knowledge claims (Hofer & Pintrich, 1997).

The research and theory on personal epistemology has taken three primary directions. Many early theorists described a developmental trajectory, suggesting that beliefs about knowledge change in a predictable pattern over time from a conception based upon certain, right–wrong knowledge, to a set of beliefs that allow for multiple views and uncertainty to a final set of beliefs in which knowledge is seen as evolving and contextual, but where knowledge is evaluated by evidence and justification (Baxter Magolda, 1992; Belenky et al., 1986; King & Kitchener, 1994; Kuhn, 1999; Perry, 1970). A second direction of research and theory proposed that an individual's epistemology is not necessarily developmental, but rather an independent set of beliefs about the sources and processes of knowing (Schommer, 1993, 1994). This direction proposes that different beliefs about, for example, the role of authority as a source of knowledge, can be measured on a continuum from simple to more complex, but that the beliefs themselves are relatively independent. Although research concerning these individual sets of beliefs has been pursued by many (e. g., Bendixon et al., 1998) there has been substantial disagreement regarding the measurement of these belief systems and the number of and nature of these beliefs in learners. Finally a third, more recent direction of theory and research suggests that instead of a relatively firm set of individual beliefs about knowledge, individuals may operate from a set of environmentally contextual epistemological resources which vary according to the situation (Hammer & Elby, 2002). This direction of research proposes that the belief structures that form a personal epistemology are even less coherent and consistent than the previous two theoretical directions have suggested.

In this chapter we briefly explore research on both personal epistemology in cross-cultural contexts and relationship of personal epistemology to learning. We then review conceptual and research literature that examines how an individual's epistemological beliefs may vary across different knowledge domains, summarizing the results of a series of qualitative studies we have conducted concerning domain-specific epistemologies. Next we examine some of the research on the relationships among instructional practices, teachers' epistemological beliefs and students' personal epistemology. Finally, we address the implications of this work for how our understanding of these personal epistemologies might better inform instructional practices.

16.2 Epistemology and Learning in Cultural Context

In this section we briefly review literature on personal epistemology, with a particular focus on research from cross-cultural contexts (for a more complete discussion of this topic, please see Part II in this volume). We also provide a limited review of research connecting personal epistemology to learning. This section is followed by a more in-depth discussion of the theoretical and research literature on domain-specific epistemologies.

16.2.1 Culture

Culture can be defined as "the collective programming of the mind which distinguishes the members of one human group from another" (Hofstede, 1980, p. 25). People in a particular culture share common experiences such as languages, values, norms, and other psychological attributes and culture is posited to have a potentially profound impact on people's attitude and behavior (Boone et al., 2004). The continuum of individualism to collectivism is a commonly used framework for understanding national and/or cultural differences (Boone et al., 2004; Earley & Erez, 1997). This theory refers to the degree of separateness or connectedness of individuals and groups (Triandis, 2001). Cultures described as individualistic are characterized by ties between individuals that are loose and where members give priority to personal goals and endorse self-reliance and autonomy. In contrast, in a collectivist culture individuals are integrated into strong cohesive groups (Hofstede & Bond, 1988) and give priority to goals shared by other members of the culture (Triandis, 1990). Western countries, such as the USA and many European countries, are generally thought of as being highly individualist in nature where as Asian countries, such as People's Republic of China are more collective oriented (The Chinese Cultural Connection, 1987; Hofstede & Bond, 1988).

16.2.2 Culture and Personal Epistemology

While much of the research on epistemology has been conducted in the USA, a few tests of the theoretical models of personal epistemology have also been conducted in contexts in other countries. Zhang and colleagues (Zhang, 1999; Zhang & Hood, 1998; Zhang & Watkins, 2001) explored the assumptions of Perry's developmental theory with Chinese students and found that the trajectory of Perry's theory did not seem to apply in the Chinese context. In particular, Chinese students' intellectual development did not progress from dualistic to multiplistic to contextual thinking. Instead, advanced Chinese university students were more likely to evidence dualistic beliefs than were their younger counterparts, a finding which is exactly opposite of the pattern observed in the USA sample.

Similarly, Schommer's theory of epistemological beliefs has been tested outside the USA with mixed results. Schommer's structure of epistemological beliefs appears generally to apply to the Norwegian (Bråten & Strømsø, 2005) and Spanish (Cano, 2005) contexts. Studies in other contexts, however, have found discrepancies with the underlying structure of Schommer's instrument for measuring epistemological beliefs. Chan and Elliott (2004) reviewed several studies from Asian countries and noted differences in epistemological beliefs among Chinese, Taiwanese and USA samples. Using an epistemological beliefs instrument first developed by Jehng (Jehng et al., 1993), Youn's research with Korean and US students also found different underlying factor structures of epistemological beliefs (Youn, 2000; Youn et al., 2001). Further, Youn found that the US samples' epistemological beliefs consistently varied by age and major. Both US and Korean students majoring in soft fields such as the liberal arts and the social sciences evidenced higher scores on the knowledge subscale (more complex views of the nature of knowledge) than did students majoring in hard fields such as science or engineering.

Karabenick and Moosa (2005) studied epistemological belief structures in the sciences for students from Oman and the USA and noted some similarities and some differences. For the Omani sample there were some notable gender differences that did not arise in the US sample: Omani men were more likely to rely on authority than did Omani women. Both Omani male and female students were also more likely than US students to express the view that knowledge in sciences is simple and certain. The samples expressed similar views about the use of evidence in justifying scientific truths.

Arredondo and Rucinski (1996) also noted differences in epistemological beliefs between Chilean and US teacher/principal samples. All US teachers were involved in a reform effort designed to help teachers develop an understanding of current cognitive research and apply those research results to their teaching; a portion of the Chilean teachers were involved in a similar reform effort and the remainder constituted a control. The researchers found significant differences between the two groups of teachers on five of the 12 previously defined subscales from the Schommer instrument. The "direction" of these differences was mixed with the US teachers showing more complex epistemological beliefs for dimensions (derived from Schommer's factor analysis of the instrument) such as "criticizing authority," and the notion that an individual "can't learn how to learn" while Chilean teachers showed more sophisticated beliefs for "avoiding ambiguity" and "concentrated effort is a waste of time." The mixed set of outcomes prompted the researchers to conclude that perhaps cultural bias in the Schommer instrument made it invalid for assessing Chilean teachers' epistemological views.

Other researchers have developed their own methods for exploring aspects of personal epistemologies in cross-cultural contexts. Alexander and Dochy (1995) investigated the conceptions of both knowledge and beliefs among Dutch and American student and working adult samples and observed differences across the two cultures as well as differences across various educational levels. In this qualitative study, the researchers asked subjects to discuss various physical representations of the possible relationship of knowledge to belief. They found considerable variation in their samples depending upon cultural background and also level of educational attainment. At the level of university students, Dutch samples were more diverse in their views of the relationship of knowledge to beliefs than their US counterparts. In contrast, at the advanced levels, US experts showed more diversity in their responses and as a whole were more tentative in their explanations than were the Dutch experts.

Differences in the underlying ontologies of knowledge were also noted for Nepali and Swedish students (Dahlin & Regmi, 2000) in another qualitative study. The researchers asked students in both countries questions about a riddle on the fundamental nature of knowledge and knowing. Their qualitative analysis suggests that students from the west (Sweden) express a more individualistic conception of knowledge whereas the Nepali sample's explanations articulated a more socially connected view of knowing and knowledge.

In a study of subcultures within a single country, Tasaki (2001) suggests that epistemological beliefs may even vary for American students from Western versus East Asian subcultures. On a measure of self-culture representation (Singelis & Brown, 1995), a more independent self representation was positively related to the more complex levels of both knowledge certainty and views of authority. Tasaki suggests that, given the relationship between epistemology and current instructional systems in US education, students from Western subcultures may be advantaged over those students whose home cultures stress interdependence over independence.

The cross-cultural epistemological research summarized earlier cumulatively supports the notion that personal epistemology may be influenced by cultural context, and in some cases introduces concerns about cultural bias in instrumentation. In particular, studies comparing cultures with a "collectivist" versus "individualistic" value system seem to produce the greatest differences in epistemological belief systems. Similarly, measures which tap into beliefs about the role of authority in transmitting knowledge appear to be particularly sensitive to cultural effects. The research also suggests that cultural groups within a given country may exhibit different epistemologies, potentially confounding research studies that treat a single country as a coherent cultural entity.

16.2.3 Personal Epistemology and Learning

Intuitively, an individual's personal epistemological beliefs seem to be related to their educational experiences, but this relationship has also been demonstrated empirically. Although a complete review of this literature is beyond the scope of this chapter, we summarize a sampling of research studies to illustrate this connection. In studies in the US epistemological stance has been shown to be related to students' overall academic performance as measured by grades (Hofer, 2000; Kardash & Howell, 2000). Students with more complex epistemological beliefs had higher academic achievement. Cano (2005) argues, however, that for his Spanish sample, this relationship was mediated by the students' approaches to learning. Zhang and Watkins (2001) found that level of cognitive development was related to achievement for their U S sample but it was not predictive of academic achievement for the Hong Kong sample. In contrast to such results, Tsai (1998b) noted that among Taiwanese eighth graders, Science Epistemological Beliefs were not correlated with science achievement.

Differences in epistemological beliefs have been shown to relate to text comprehension (Schommer et al., 1992; Schraw et al., 2002), cognitive strategies (Kardash & Howell, 2000), and conceptual change (Qian & Alvermann, 1995) among university students in the USA. Mason and Boscolo (2004) studied the relationship of level of text comprehension to epistemological stance for high school students in Italy. They found that students with a dualistic epistemology were less capable at interpreting the issues involved in a controversial text than were students who expressed more complex epistemologies.

Epistemological beliefs within a disciplinary domain appear to be strongly related to learning within the discipline. For example, simple beliefs regarding the nature of historical knowledge may impede problem solving within that discipline (Wineburg, 1991). Science educators in both the USA and other countries have thoroughly investigated the relationship between learning and the individual's epistemological beliefs about sciences (Edmondson & Novak, 1993; Roth & Roychoudhury, 1994; Ryder & Leach, 1999; Ryder et al., 1999; Tsai, 1998a; Westby & Samarapungavan, 2001). This research, often embedded in investigations of individual's beliefs regarding the "nature of science," cumulatively suggests that simple epistemological beliefs regarding the knowledge in science may restrict students' use of active and inquiry-based learning strategies in science. Indeed, Jonassen et al. (2004) argue that less complex epistemological stances can impede student learning in any constructivist learning environment.

In a study of Norwegian postsecondary students, Bråten and Strømsø (2005) found that the effects of students' epistemological beliefs were stronger than the effects of students' implicit theories of intelligence on their self-regulated learning strategies. The exact nature of the relationship varied by academic major. Similarly, Lonka and Lindbloom-Ylanne (1996) found that students who expressed a dualistic epistemology were also more likely to describe a passive approach to learning. Students with a more evaluativist epistemology were more likely to use constructivist learning approaches. In a comparison of Chinese and US sample, Zhang and Watkins (2001) reported that while the overall assessment of level of epistemology differed between the two samples, the relationship of epistemology to learning approaches were the same for US and Chinese students.

16.3 Domain-Specific Epistemology

Having reviewed background research regarding personal epistemology, culture and learning, we now turn to personal epistemology in different disciplinary domains. There has recently been a proliferation of research (Muis et al., 2006) which investigates the effect of knowledge domain (i.e., academic discipline) on personal epistemology. The theory regarding whether and how personal epistemology is influenced by knowledge domain is still developing however many theorists have begun to envision a tentative relationship between general and domain-specific personal epistemologies which is nested and connected. In other words, an individual may describe a relatively stable general epistemology, but subsumed under that general epistemology is a series of domain-specific epistemologies that may or may not be consistent (Buehl & Alexander, 2006; Hofer, 2006).

In their review of 19 empirical studies investigating the question of domain-generality versus domain-specificity of epistemological beliefs, Muis et al. (2006) found evidence for both sets of beliefs. They argue that the evidence across these various studies points to an interactive relationship in which student may hold somewhat disparate beliefs in different domains. These domain-specific beliefs, at the same time, may loosely correlate with an overall set of domain-general beliefs. All but one of the reviewed studies employed quantitative research designs.

Our research has explored the phenomenon of domain-specific personal epistemologies through in-depth qualitative interviews. During the course of a larger study of personal epistemology of science and engineering university students, the authors noted that a number of students, when asked about the nature of knowledge, would make a distinction between knowledge in sciences versus knowledge in contrasting domains such as the humanities or social sciences. We then began investigating this phenomenon systematically and developed an emergent theory regarding distinct personal epistemologies in different knowledge domains grounded in data from student interviews (Palmer & Marra, 2004). We have also conducted a follow-up validation of our grounded theory with a different sample of students majoring in the liberal arts (Palmer & Marra, 2006). Interview data from a total of 90 third and fourth year university students informs our discussion of domain-specific epistemological beliefs.

Across samples, we found patterns of epistemological perspectives that expressed a simple dualistic epistemology, a multiplistic epistemology and a more complex, evaluativist epistemology for two knowledge domains: Sciences and Humanities/Social Sciences. Figures 16.1 and 16.2 present a condensed view of the epistemological orientations in the knowledge domains as expressed by the two samples of university students. Although the studies were not longitudinal and therefore cannot provide evidence of development, individual students themselves described the change in their epistemological orientation in terms that often implied a developmental progression. For example, this student expressed a changed

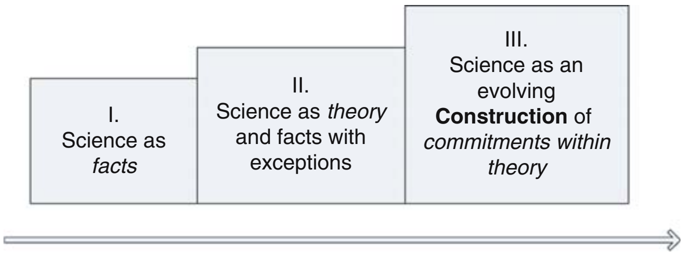


Fig. 16.1 Epistemological orientations for science

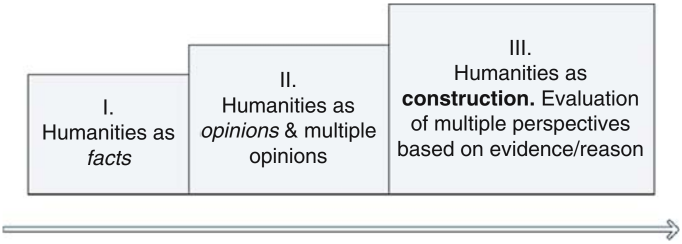


Fig. 16.2 Epistemological orientations for the social sciences/humanities

understanding of knowledge in the sciences and clearly describes his development evolving from an earlier dualistic belief about knowledge in the sciences toward a more complex epistemology.

> As far as engineering classes, what I used to think was that everything was factual, based on numbers. Now I think that everything is not factual. Some things – we just can't describe.

These findings in and of themselves are not surprising, as they complement the epistemological theories and research described earlier. What makes this research distinctive, however, is the number of students in both samples (approximately 78%) who expressed views of the nature of knowledge and knowing that are *inconsistent* across the two knowledge domains. Table 16.1 shows the relative epistemological categorizations for individuals from both studies. While the distribution of the sample across the three relative position combinations is of interest, the fact that only 21.9% of the subjects showed "equal" epistemological stances provides strong support for domain-specific epistemologies.

Additional direct evidence of domain-specific epistemology comes from our second study of liberal arts students where all 30 students in the sample were asked directly "Do you view knowledge differently in the sciences and the humanities?" Seventy percent indicated they did perceive a difference, only 17% said "no," and 13% did not directly respond to the question. While our categorization of epistemological orientations considers more than the simple answer to this question, this result provides persuasive evidence of the domain-specificity of epistemological beliefs.

Students often described their contrasting domain epistemic beliefs directly as exemplified by the following quotation:

> [Humanities] is all open for interpretation.… Everybody gets a say in the matter. There isn't a textbook I can open up and say this is the answer to world hunger. This is the answer to crime in America. Whereas in science you open up the book and say this is how you do calculus. This is how you find a sign wave. You can't do that in humanities. *I think knowledge is very different*. [emphasis added].

The above quotation exemplifies a student who describes a multiplist epistemological stance (H/SS II) in the social sciences while, at the same time, employing a dualistic epistemological stance in the sciences (SCI I). This is the predominant

Table 16.1 Science/social science – humanities relative orientation categorization and frequencies

Orientation Science > SS/ Humanities				Orientation Science = SS/Humanities				Orientation Science > SS/Humanities			
Science	SS/ Hum	Orig.	New	Science	SS/ Hum	Orig.	New	Science	SS/ Hum	Orig.	New
								I	I–II	0	1
II	I	1	0	I	I	1	0	I	II	17	5
II	I–II	1	0	I–II	I–II	2	0	I	II–III	0	6
II–III	I	1	1	II	II	8	2	I–II	II	7	10
II–III	II	8	2	II–III	II–III	2	1	I–II	II–III	1	
III	II–III		1	III	III	2	0	II	II–III		1
								II–III	III	1	
Total = 15 (18.3%)		11 (21%)	4 (13%)	Total = 18 (21.9%)		15 (29%)	3 (10%)	Total = 49 (59.8%)		26 (50%)	23 (77%)

Note. Original sample size was N = 90 for the combined samples. However, eight students did not provide clear evidence for ratings in one or the other domain and therefore are excluded from the present table.

relative stance of students from both samples (27%, see Table 16.1). However, not all students exemplified these epistemic belief patterns. A few students exhibited an evaluative epistemological stance (orientation III) in the humanities/social sciences or science or both.

Also, in contrast to the results from Muis et al.'s (2006) review of quantitative studies, in our sample, students did not exhibit a singular predictable pattern of more advanced beliefs in one domain or another. Muis's hypothesized predictable pattern of domain-specific epistemological belief is based upon the nature of the knowledge domain under discussion; she posits that some domains have stronger paradigmatic underpinning and thus, more certainty about knowledge. In the authors view, then, differences in domain-specific epistemologies are partially explained by the nature of the discipline and its patterns of justification of knowledge claims. Therefore, students' epistemological beliefs in domains that might be categorized as soft (Biglan, 1973) would more likely be multiplistic or evaluativist while students epistemological beliefs for hard domains would more likely be dualistic.

While the majority of the students in our samples do evidence a more advanced set of epistemological beliefs in humanities/social sciences (soft domains) some of our students evidenced more sophisticated (i.e., multiplistic or evaluativist) beliefs in sciences. For example, this student describes a dualistic stance (H/SS I) in History and a more multiplistic stance (SCI II) in the engineering:

> Well yeah definitely because truth in history, for the most part, history they're facts. They're documented, they're there. And say like in science or in engineering, it's all pretty much based on hypothesis.... You state assumptions and there you could have the truth there. So depending on what you assume it could be true or not.

If the nature of the domain (hard–soft, pure–applied) were the predominant influence on student's epistemological beliefs in that domain, then we would expect a more predictable pattern of simple beliefs in the sciences and more complex beliefs in the humanities and social sciences. In our samples however, this predicted pattern occurs only 60% of the time. We believe, based on evidence from our interviews with students, that the instructional contexts and pedagogical tactics employed in a domain may play a more important role in shaping students' epistemological beliefs within that domain than domain characteristics.

We hypothesize that students may more easily make the leap from dualistic to multiplistic epistemology in the social sciences and humanities because instruction in these disciplines often focuses on the variety of theories available to explain social phenomenon. Class discussions and debates, writing essays, hearing an instructor's view that differs from or expands on what the text says, and assessment systems that encourage independent thinking may lead students to believe that these disciplines are composed of many opinions. As we see in the next quotation about a humanities instructor, students' epistemological development can be encouraged by thoughtful instructional approaches.

> [T]he study of two opposing views and how they interact with each other. And she [the instructor] had her own opinion. And she said the first day...'this is my opinion. I'm telling you right now just so you know.'

This hypothesis is supported by Jehng et al. (1993) and Paulsen and Wells (1998) who both found that students in the soft fields (which are arguably would include the social sciences and the humanities) make the leap to an understanding of knowledge as non-static more readily than do students in "hard" science fields. However, the limited number of students in our studies, particularly in the science/engineering subsample, who demonstrated an evaluativist epistemology in the social sciences and the humanities (nine in total in SS/Humanities II–III or III) suggests that students may not be internalizing the underlying justification process of instructional techniques which expose students to multiple views on a topic.

The shift from a multiplistic epistemic orientation to an evaluativist stance, we believe, is a more difficult epistemological transition, an argument which is supported by Perry's original discussion of the university experience for the students in his study (Perry, 1970, 1981). Based upon evidence from our interviews, students were likely to make the transition from multiplist to evaluativist positions either through a long exposure to a domain or through specific curricular experiences. In particular, all but one of the liberal arts sample students who expressed an evaluativist stance in sciences had taken a considerable number of courses in that domain. Of course, extended exposure to a domain is not enough in all cases as many junior and senior science and engineering majors still described a relatively naïve epistemic view of science.

We hypothesize that particular types of pedagogical experiences may also help students make the transition from multiplist to evaluativist orientations. Interviews from our science/engineering student sample provide evidence that advanced courses that offered experiences such as ill-structured problem-solving projects helped students to develop advanced understandings of knowledge in the sciences. This finding is consistent with Westby and Samarapungavan's (2001) work on expertise that showed the positive effect of graduate student research activities on the depth of processing in problem solving activities.

16.4 Personal Epistemology and Instruction

So far in this chapter we have reviewed research and conceptual frameworks concerning general epistemology, epistemological differences (and similarities) in different cultural settings and evidence to support domain-specific epistemologies for individual learners. As this volume attests to, researchers and educators would not be very interested in epistemology unless it also has practical implications for learners and instructors. We now turn our attention the implications of differing contextual and domain epistemologies for instruction and learning. We envision this relationship as reciprocal, with instruction affecting epistemology and epistemology also affecting how students experience instruction. In addition, we provide evidence that instructor's epistemology may impact their instructional choices and therefore, learner experiences. Initially, we focus our discussion on instructional interventions that can positively impact epistemology.

16.4.1 Epistemology and Teaching and Learning

There is a body of research to indicate that properly structured instructional activities can have a positive impact on student epistemological beliefs. For example, Stephenson and Hunt (1977) developed an intervention based on the Perry scheme that was designed to encourage first-year students to move from dualist positions to a more relativistic stage in a general education course. The researchers operationalized an underlying assumption; namely that intellectual development occurs as a result of "cognitive conflict or dissonance which forces individuals to alter the constructs they have used to reason about certain situations" (Widick et al., 1975, p. 291). In pretest and posttests using the Perry scale the students in the experimental course section showed substantially greater movement than their counterparts in the control group.

Pascarella and Terenzini (1991) report on two other studies that examined course interventions specifically aimed at advancing students' cognitive development as measured by the Perry scheme (Knefelkamp, 1974; Widick & Simpson, 1978). Similar to Stephenson and Hunt, both interventions designed instruction to match students' current intellectual development and found that a greater percentage of the students in the experimental section showed growth on the Perry scale than those in the control group. Hill (2000) reports similar results with a sample of preservice teachers who participated in a course designed to promote intellectual development. Teachers who participated in the experimental course showed statistically significantly higher differences in epistemological beliefs as measured by the Perry scheme-based MID (measure of intellectual development) than those in the control.

Valanides and Angeli (2005) also found that instructional interventions designed to teach critical thinking skills impacted epistemological beliefs. Undergraduate students were assigned to one of three instructional approaches – general (where critical thinking skills were taught isolated from any context), infusion (students practiced critical thinking within a subject area and principles of critical thinking were made explicit) and immersion (the same as infusion except critical thinking principles were not made explicit). Epistemological beliefs were measured by a forced response instrument based on interview questions from King and Kitchener's protocol (King & Kitchener, 1994) and asked respondents to rate the importance of a controversial issue, provide a reason on how experts could disagree about the issue, ascertain their level of "correctness" in their stance on the issue, and explain how their beliefs could be justified. Results showed that the infusion group had significantly greater post epistemological beliefs than did the general group (but not the immersion group) indicating that some change in epistemological beliefs may be attributed to the instructional strategies used.

Marra et al. (2000) also report a statistically significant impact in Perry ratings for engineering students who completed a first-year design course. Although this course was not designed to intentionally affect Perry ratings, students who completed the course had Perry ratings that were statistically higher than their counterparts, who listened to lectures,

16.4.2 Teacher Epistemology and Instructional Practices

From the research just described, it is clear that the strategies and activities teachers choose to implement can have an impact on student epistemological beliefs. However, teacher choices regarding the design of instructional environments, not surprisingly, may also be affected by the teachers' epistemological beliefs. The proposed link between teacher epistemological views, their teaching methods and ultimately the impact on not only students' learning outcomes but students' epistemological beliefs has been well documented. Essentially, researchers have argued that teachers with more advanced epistemological beliefs will employ teaching and learning strategies that can, in turn, promote more advanced student epistemological views. For instance, White (2000), found that teacher epistemological beliefs impact how teachers approach classroom problems. Their study found that preservice teachers that held predominantly dualistic beliefs tended to have more simplistic view of classroom problems and drew mostly on only their own personal experiences of similar problems when working on solutions. Alternatively, teachers with more sophisticated epistemological views sought out alternative resources and viewpoints in their attempts to problem solve.

Hashweh (1996) conducted a study in Palestine framed around the constructs of constructivist or empiricist views held by teachers. Arguably constructivist beliefs that indicate that knowledge is constructed from multiple perspectives are in alignment with more sophisticated understandings of what knowledge is and thus more sophisticated epistemologies. Hashweh's study of 35 science teachers used a survey instrument to categorize teachers as either "constructivist" or "empiricist." In a subsequent analysis of teachers' responses to critical incidents, Hashweh found that the teachers who held constructivist beliefs were more likely than the empiricists to explore a students' alternative understanding of the content or problem at hand rather than dismissing such an alternative view. Constructivist teachers also had a richer set of teaching strategies to draw upon and were more likely to try to promote student conceptual change than their counterparts who held empiricist beliefs.

Johnston et al. (2001) also examined the relationship between teacher and student epistemological stances with a focusing on how beliefs evidenced themselves in teacher and student dialog. Two teacher cases were examined; both teachers were selected for being "competent" elementary teachers but they evidenced contrasting epistemologies – one holding a more traditional view of teaching and learning that revolved around receiving and transmitting knowledge, while the other espoused a view of knowledge as being constructed. The researchers found that the "traditional" teacher used more monologic dialog that centered around right and wrong answers and limited complex issues that might occur during student learning. In contrast, the constructivist teacher used "we" in her classroom dialog and consistently indicated ownership of knowledge and learning was distributed between teachers and students rather than assuming an authoritative stance. These teacher activities were also found to impact students' understanding of knowledge in their classrooms.

In a case study of preservice elementary teachers, Slekar (1998) found that in spite of participating in constructivist-based methods courses, student teachers felt unready to use instructional strategies that reflected more complex epistemologies. The preservice teachers specifically noted that methods courses lacked opportunities for guided reflection which they felt may have helped to better prepare them for using more epistemologically sophisticated methods in the classroom. Such guided reflection could have served as a means for teachers to examine their beliefs in the framework of the new theory and practice they encounter in their methods courses.

Studies from Hill (2000) and Gill et al. (2004) investigated the impact of course activities on preservice teacher epistemological beliefs. Hill (2000) had preservice teachers work actively in schools to provide them the opportunity to link theory with school-based practice. An additional key course component was the presence of multiple and conflicting perspectives on pedagogical issues. Results of the Perry-based MID showed a statistically significant increase in intellectual growth for the experimental group versus the control. Similarly, Gill et al. (2004) examined the impact on preservice math teachers' epistemological beliefs of two methods previously shown to induce conceptual change in learners – refutational text and augmented activation. Results of their study indicated that these methods did promote greater change in epistemological beliefs about mathematics for the experimental group preservice mathematics teachers.

Author Marra (2005) also investigated how teacher beliefs can be impacted but used a different methodology. This qualitative study examined how participation of seven university faculty in the design of computer-based learning environments based on constructivist principles impacted their beliefs about teaching and learning. Results indicated that there existed a "zone" of preexisting beliefs and teaching activities that allowed faculty to experience a change of beliefs concurrent with participating in the design of the environment. Teachers needed to be somewhat open to more sophisticated views of what knowledge is, but not yet embracing such beliefs in their teaching methods. Teachers that fell to either side of this "zone," either already implementing constructivist methods or firmly grounded in teaching and learning revolving around right and wrong knowledge, did not show a change of beliefs as a result of participation.

16.5 Discussion – Domain-Specific Epistemology Informing Educational Practice

This chapter – and this entire volume – confirms that personal epistemology – like its subject matter, knowledge, is a complex topic. We have reviewed research on epistemology from a variety of perspectives with a focus on domain-specific epistemologies. We now weave these perspectives together into a model which can be used to inform educational practice.

As a heuristic to better understand the complex relationships among constructs such as culture, domain, and the individual's developing personal epistemology, we

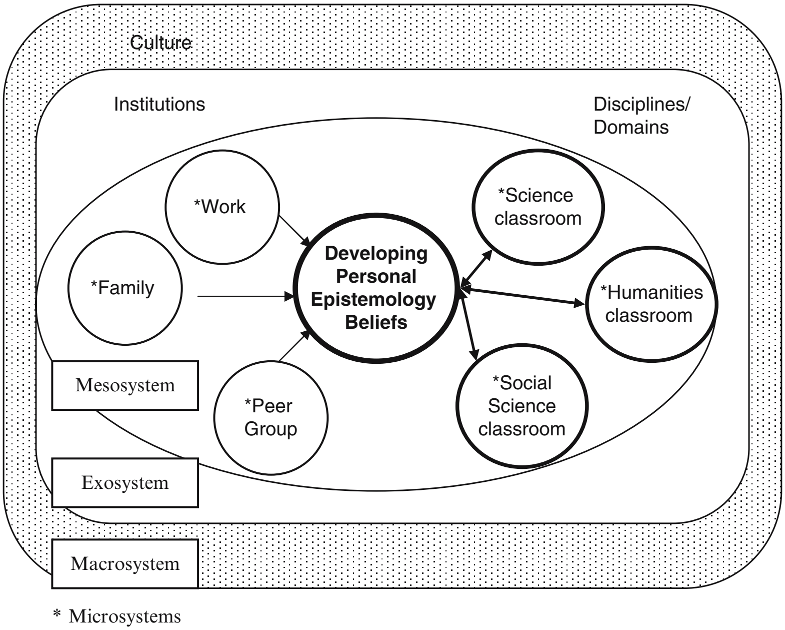


Fig. 16.3 An ecological model of personal epistemology

propose an ecological model of personal epistemology in the tradition of Urie Brofenbrenner (Brofenbrenner, 1977; Brofenbrenner & Evans, 2000). In a human ecology model such as the one illustrated in Fig. 16.3, the individual's developmental trajectory is influenced by a nested arrangement of reciprocally related environments. The most proximal environments (microsystems) are the face-to-face interactions of the individual in social settings. A microsystem is any daily activity in which the individual engages in a social role, such as the role of student, worker or friend. These elements are denoted by the asterisk-marked circles in Fig. 16.3. For any given individual at a point in time, a series of microsystems creates the mesosystem – the various social environments of their daily lives. The more distal environments, the exosystem nested within the macrosystem, influence not only the individual's personal development, but also the environments of the mesosystem. All of these systems change over time, creating a complex model which is a person-process-context-time ecological model.

In this ecological approach, the elements of the individual's microsystem, being more proximal to the individual, will exert a more direct influence on epistemological beliefs than the more distal exosystem or macrosystem. In addition, at any given point in development, certain characteristics of the individual will affect how the social system impacts development. For example, individuals may be more open to or more resistant to change at different points in time. Individuals may also be selectively responsive, that is, at a given point in time, they are simply paying more attention to elements in the environment which affect a particular aspect of development. This is consistent with Marra's (2005) finding, described earlier, for the impact on epistemological beliefs of faculty who were engaged in developing constructivist learning environments. Only faculty somewhat open to more sophisticated views of what knowledge is, but not yet embracing such beliefs in their teaching methods experience epistemological growth from the experience.

In translating this model to the development of personal epistemology, we can see that while both culture and the knowledge domain may exert an influence on the development of personal epistemology (in the macro and exo systems), the more proximal microsystem classroom setting, in particular instructional and assessment practices, is theorized to exert a stronger and more direct influence on the individual's epistemology. In Fig. 16.3 these aspects of the microsytem are denoted in bold. This hypothesized relationship fits well with the research findings regarding epistemological resources (Hammer & Elby, 2002) that posit that the individual accesses epistemological resources based upon the immediate demands of the classroom environment.

Disciplinary or domain characteristics from the exosystem will also affect the individual's developing personal epistemology, but the influence would be indirect, occurring primarily through the filtering mechanisms of the microsystem of the classroom. This makes intuitive sense, in that, for most students, their introduction to and socialization in a discipline takes place initially in classroom settings, guided by instructors. This aspect of our model is similar to the one proposed by Buehl and Alexander (2006) who position the individual's belief systems as nested within the sociocultural environment.

Our view that the relationship of classroom practices to personal epistemology is particularly potent is again grounded in evidence from students' interviews. We examined the transcripts of the liberal arts student sample for the students' own perceptions of instructional practices in science classrooms. Twenty-five of the 30 students provided adequate descriptions of their perceptions of science instruction. Of the 17 students who expressed more dualistic epistemologies in science, 16 also described the pedagogy in sciences as traditionally teacher-centered, and often consisting of lecture and procedural-oriented lab experiences. In contrast, half of the students who expressed multiplist or evaluativist epistemologies also described science pedagogy as at least partially constructivist or student-centered.

This evidence considered in combination with the ecological system we propose, and in particular the impact of the classroom microsystem on students, can also partially account for the evidence we have seen of individual students holding domain epistemological stances which appear to be inconsistent. If pedagogical activities in a particular domain tend to entail certain types of epistemological assumptions (e.g., science is content based and thus prescribes lectures and multiple choice tests), then students' beliefs about knowledge in that domain may be nudged into alignment with the underlying ontological assumptions of the pedagogical strategies.

Previous research (De Coret et al., 2002; Kloosterman et al., 1996) supports this idea and indicates that students respond to the messages that teachers send to them about classroom expectations. For example, Schoenfeld's (1985) work shows that students may be aware of teacher's spoken expectations about what is important in the classroom (e.g., statements on syllabi, the benefits of group work) but may adopt such beliefs at only a rhetorical level rather than one of deeply held beliefs. He further indicates that students do not have difficulty espousing these rhetorical beliefs but acting (in classrooms) in completely contradictory ways. It is not difficult to imagine that students could respond with behaviors they believe to be appropriate whether it corresponds with their domain epistemological beliefs or not, a conceptual distinction described by Limon (2006) as enacted versus professed epistemologies.

While particularly powerful, in the model we present, a particular classroom is only one of many microsystems which can influence the students' developing personal epistemology (either domain general or domain specific). For students who have developed a more sophisticated epistemology, instructional approaches based in simple epistemologies can be frustrating. The following student who demonstrated an evaluative epistemological stance comments on traditional approaches to teaching science.

> They [science instructors] seem to think of themselves as pretty high and mighty and so everything they teach, they teach as absolute truth. In reality, it is based on what we know right now.

For many university level students, the academic environment takes over a significant portion of their daily lives (the mesosystem) while they are enrolled in classes. They are immersed in a world of academic knowledge. This may explain in part why researchers have found research focused on university level student personal epistemological development so fruitful. Perry (1970) described the transition to university life as one in which the individual is exposed to and is encouraged to explore a diversity of ideas. In terms compatible with the ecological model, the individual is submerged in a variety of microsystems which can present challenges to their existing personal epistemologies and thus provides impetus for epistemological growth.

16.5.1 Implications

The implications for teachers, instruction, and higher education institutions of our research and the proposed ecological system of individual development are, of necessity, systemic in nature. Although Fig. 16.3 depicts a system where the micro environment may exert the most direct impact on students' epistemological beliefs, it also helps us to visualize how the entire environment of the university can be important. The pedagogical entailments of the system we have proposed are neither solely in the micro nor in the macro portions of the system but rather have implications throughout. The following implications for promoting the epistemological growth of learners are discussed in terms of both microsystem and exosystem interventions.

16.5.2 Microsystem Interventions

As we proposed in our discussion earlier, activities at the individual course level may have the most direct impact on student epistemological beliefs. The potential for positive impact of certain pedagogical activities (e.g., open-ended problems in a supported environment) on students' general epistemological beliefs has been described earlier. However given our research that shows evidence of varying domain epistemological beliefs in individual students, we propose additional strategies at the micro level for encouraging epistemological growth that may capitalize on these domain differences. We note as well that many of these suggested strategies require cooperation across academic units and disciplines and thus have implications at multiple levels of the ecological system we propose.

At the core of classroom strategies that can take advantage of learner domain-specific epistemological belief systems is an understanding of domain knowledge existing in a context *with* other domain knowledge rather than isolated from other domain knowledge. If instructors, and in turn students, can be aware that knowledge in the sciences, for example, exists in the same broad context as social science knowledge, one can begin to see that the ways that we come to have knowledge in either domain may have similarities. A recognition of these similarities could potentially encourage learners to explore the idea that knowledge in, for instance, the sciences – which they have always thought of as being either right or wrong and coming as "Truth" from a text book – may be similar in structure to knowledge in the humanities – of which they have held a more sophisticated view. The possibility that a reflective student might consider these ontological relationships as she contemplates her science class knowledge while reading a newspaper discussing global warming has always existed. However, we posit that if instructors can both foster in students a view of domain knowledge existing in a broader context and employ instructional strategies to support this idea, change or even an openness to change in epistemological beliefs may be more likely to occur.

The presence of instructional strategies may be critical to such changes. As quotations from our data support, students may be frustrated by attempts to help them understand knowledge in a way they have either already surpassed or, alternatively, are not prepared for. For the latter, having students engage in open-ended projects that have a cross-disciplinary component may provide opportunities for development. For instance, an engineering design project required of first-year students may require them to not only ensure that their designs function as required (e.g., crush a can, or sort bolts) but also require that students consider the budget, and how the new tool might impact the community in which it will operate (e.g., environmentally, economically).

Students may initially have difficulty bringing "soft" knowledge into their engineering coursework, but the presence of this contrasting domain knowledge, when supported by instructors, may spur reflection by students on the nature of knowledge in both domains. Further, instructors could very directly prompt (as illustrated in Fig. 16.4) students to use their ways of knowing from the humanities, say, in their engineering courses by posing questions and suggesting strategies for accomplishing course work.

Assessment strategies provide another opportunity to capitalize on domain-specific epistemological differences (Biggs, 1987). As instructional designers have emphasized repeatedly, assessment strategies must be aligned with pedagogical activities in order for instruction to be effective (Dick & Casey, 1996) We further argue that assessment strategies – as much if not more so – than instructional

- How do you know your design is the best it could be? How would you figure that out?
- Well, how do you figure out that you have written your best essay for your American History class?
- So you are saying there are potentially multiple best ways and best essays? How can that be?
- Could that be the case in this course? How?

Fig. 16.4 Questions to help students compare knowledge structures across disciplines

strategies also communicate domain epistemologies to students. In the particular case of personal epistemology, classes which, for example, discuss multiple perspectives on an historical event but then use true–false examinations implying a singular truth for evaluation, will present students with conflicting messages about the nature of historical knowledge. Students can be quite articulate about their perceptions of the demands of the learning environment and will adjust their learning approaches accordingly (Entwistle & Peterson, 2004) so it is imperative that pedagogical activities are aligned with instructor goals for learning and, we would argue, promotion of epistemological beliefs.

We recognize that these are not new suggestions for creating learning environments that promote meaningful learning. In fact, these are pedagogical strategies that have been proposed to impact other desirable learning outcomes such as critical thinking (Kardash & Howell, 2000), and conceptual change (Gill et al., 2004). However, we do posit that understanding the impact that these pedagogical activities can *also* have on developing epistemological beliefs provides further evidence and weight to the argument that we must reform university education if we are committed to graduating students who can critically analyze and solve the complex problems they will undoubtedly face in their work and personal lives.

Beyond these instructional strategies, we also suggest that simply making instructors, curriculum designers and administrators *aware* of these potential individual domain epistemological differences could impact instruction and positively impact both student learning and epistemological development. Awareness of the existence of domain-specific personal epistemologies, and in particular, of the potential impact of the classroom environment on these beliefs could be the basis for teacher reflection on their own epistemological beliefs and their connection to their pedagogical activities. The previously discussed research on teacher epistemologies and the relationship to their teaching activities (e.g., Brownlee & Berthelsen, 2006) supports the importance of this type of reflection.

There are limits to the reform of instruction, of course. We do not, for instance, believe it is feasible to tailor instruction to individual students' epistemological stances. This is untenable for several reasons. Although some instruments exist for measuring general and domain epistemology (e.g., Hofer, 2000; Moore, 1998; Schommer, 1993), it is no more reasonable that faculty would administer these instruments in every class than other instruments that measure, for example, learning style differences. Further, just as it is untenable to create individualized instruction for individual student learning styles (Jonassen & Grabowski, 1993), it is also unlikely that instructors could create and implement individualized instruction for all the epistemological stances that exist in a particular class. Nor would it be desirable. As the prior research on instructional strategies that impact epistemological beliefs shows (Gill et al., 2004; Hill, 2000), encountering and deeply considering conflicting points of view can be an effective tactic for changing epistemological beliefs. Instructors can use the multiple view points and epistemological stances that exist amongst students in a single class as a means of encouraging epistemological change.

16.5.3 Exosystem Interventions

Given the ecological model proposed, the microsystem level implications just discussed may have the potential to have the most direct impact on student epistemological beliefs. However the suggestions we have made have implications for tertiary institutions as a whole. For instance, we have suggested that instructors leverage disciplinary epistemological differences through cross-disciplinary focused course work. However, most higher education institutions – at least in the USA – implement a rewards system that is based upon faculty being given "credit" for teaching a certain number of courses in their own academic units. Having two faculty from different disciplines jointly teaching a course would require the administration to reconstruct current financial and teaching load systems which reward faculty efforts.

The involvement of the exosystem of the university would also be critical in overall curriculum changes that might take advantage of differences in domain-specific epistemologies. Many institutions in the USA have "general education" course requirements that apply to a majority of the degree programs offered. Although requirements vary from university to university, general education courses often include courses in the humanities, arts, social sciences, and sciences. They may include courses in cultural studies and languages. Because there is no incentive to do otherwise, students often choose general education courses based predominantly on convenience resulting in a set of courses that have little cohesiveness or relationship to one another. Because the courses are disjointed, they will not necessarily encourage students to see connections between bodies of knowledge and processes of knowing. There could be great potential for epistemological growth if general education requirements were designed in ways to promote cohesion. At the very least courses, say in the humanities, could be consciously designed to consider students' epistemological stances for the structure of knowledge in contrasting domains such as the sciences.

A related exosystem level reform concerns examining overall degree requirements. Many degree programs allow little room for students to take courses not directly related to their major. This type of curricular design comes from a higher education paradigm which assumes that there is a large, relatively static body of knowledge in a particular domain that must be "covered" in order for students to successfully earn a degree in that domain. This leaves little opportunity for students to encounter a cohesive series of courses in a discipline outside of their major that may help to foster epistemological advances not only in the "outside major" domain but perhaps serve as a lever for contrasting knowledge between their major domain and that of knowledge outside their majors.

We propose the somewhat radical idea that as educators we need to let go of the false belief that graduates in our major are completely prepared for their future endeavors simply because they have taken our prescribed regiment of courses. Even if we did "expose" them to all the pertinent knowledge in our domain, the likelihood that they could either remember it or use it is low. Rather, we would be better off if we have helped them to learn *how* to approach problems and *how* to think about multiple and often conflicting sources of knowledge both within and outside the major field – these are outcomes that surround developing personal epistemological beliefs. Certainly we are not arguing that an engineering major should not include mostly engineering courses. Rather we suggest that designing the curriculum so there is "space" for students to take advanced course work in other domains could provide both opportunities for taking advantage of domain-specific epistemological differences (especially if academic units worked towards horizontal course integration), as well as help to prepare graduates who continually reevaluate knowledge in their field based upon new evidence and in consideration of societal contexts.

16.6 Conclusions

Our research, and the work of researchers and theorists described above, cumulatively suggests that personal epistemological beliefs are culturally sensitive and that for a given individual, epistemological beliefs may not be consistent across disciplinary or knowledge domains. Further, our data and the research by Hammer and associates (Rosenberg et al., 2006) suggests that students' domain-specific epistemological beliefs may even be affected by specific classroom demands – and not solely by the knowledge structures of the domain itself. Our ecological model of personal epistemology provides a heuristic device for envisioning the multiple, interacting, and overlapping contexts that may influence the development of an individual's epistemological beliefs.

Although personal epistemology is of interest purely from an academic standpoint, as researchers we began our work in this area because of the real impact understanding personal epistemology can have on student learning. Our discussion of the interactive relationship of personal epistemology to instruction suggests that efforts to promote a more complex epistemology in students is, first of all, possible, and second, may have additional indirect effects on student learning outcomes. And although there is a well researched understanding of how instructional activities may impact general epistemology, the proposed model also provides a framework for thinking about the implications of domain-specific epistemologies – the focus of our work. However, as our model suggests, many of the strategies that take advantage of individual domain-specific epistemologies and that might promote epistemological development in students are themselves impacted by the nested environments of disciplines, institutions, and societies. With such a complex set of interactions potentially impacting personal epistemology, researchers can look forward to engaging in a range of future research studies to further understand these relationships. We hope that practitioners can anticipate results from these ongoing investigations that can ultimately help tertiary institutions worldwide prepare students to be effective members in our global society.

References

Alexander, P. A., & Dochy, F. J. R. C. (1995). Conceptions of knowledge and beliefs: A comparison across varying cultural and educational communities. *American Educational Research Journal*, 32(2), 413–442.

Arredondo, D. E., & Rucinski, T. T. (1996, November). *Epistemological beliefs of Chilean educators and school reform efforts*. Paper presented at the Tercer Encuentro National de Enfoques Cognitivos Actuales en Education, Santiago, Chile.

Baxter Magolda, M. B. (1992). *Knowing and reasoning in college: Gender related patterns in students' intellectual development*. San Francisco, CA: Jossey-Bass.

Belenky, M. F., Clinchy, B. M., Goldberger, N. R., & Tarule, J. M. (1986). *Women's ways of knowing: The development of self, voice and mind*. New York: Basic Books.

Bendixon, L. D., Schraw, G., & Dunkle, M. E. (1998). Epistemic beliefs and moral reasoning. *Journal of Psychology*, 13, 187–200.

Biggs, J. B. (1987). *Student approaches to learning and studying*. Melbourne, Australia: Australian Council for Educational Research.

Biglan, A. (1973). The characteristics of subject matter in different academic areas. *Journal of Applied Psychology*, 57(3), 195–203.

Boone, C., Christoph, M., & van der Velden, R. (2004, May). *Individualism and collectivism cross-national differences in the impact of culture on labor market outcomes*. Paper presented at the Research Committee 28 on Social Stratification and Mobility, Neuchâtel, Switzerland.

Bråten, I., & Strømsø, H. I. (2005). The relationship between epistemological beliefs, implicit theories of intelligence, and self-regulated learning among Norwegian postsecondary students. *British Journal of Educational Psychology*, 75, 539–565.

Brofenbrenner, U. (1977). Toward an experimental ecology of human development. *American Psychologist*, 32, 513–531.

Brofenbrenner, U., & Evans, G. W. (2000). Developmental science in the 21st century: Emerging questions, theoretical models, research designs and empirical findings. *Social Development*, 9(1), 115–125.

Buehl, M. M., & Alexander, P. A. (2006). Examining the dual nature of epistemological beliefs. *International Journal of Educational Research*, 45, 28–42.

Cano, F. (2005). Epistemological beliefs and approaches to learning: Their change through secondary school and their influence on academic performance. *British Journal of Educational Psychology*, 75(2), 203–221.

Chan, K. W., & Elliott, R. G. (2004). Epistemological beliefs across culture: Critique and analysis of belief structure studies. *Educational Psychology*, 24(2), 123–142.

The Chinese Cultural Connection (1987). Chinese values and the search for culture-free dimensions of culture. *Journal of Cross-Cultural Psychology*, 18(2), 143–164.

Dahlin, B., & Regmi, M. P. (2000). Ontologies of knowledge, East and West – A comparison of the views of Swedish and Nepalese students. *Qualitative Studies in Education*, 13(1), 43–61.

De Coret, E., Op't Eynde, P., & Verschaffel, L. (2002). "Knowing what to believe": the relevance of students' mathematical beliefs for mathematics education. In B. K. Hofer & P. R. Pintrich (Eds.), *Personal epistemology* (pp. 297–320). Mahwah, NJ: Lawrence Erlbaum.

Dick, W., & Casey, L. (1996). *The systematic design of instruction*. New York: HarperCollins.

Earley, P. C., & Erez, M. (1997). *The transplanted executive: Why you need to understand how workers in other countries see the world differently*. New York: Oxford University Press.

Edmondson, K. M., & Novak, J. D. (1993). The interplay of scientific epistemological views, learning strategies, and attitudes of college students. *Journal of Research in Science Teaching*, 30(6), 547–559.

Entwistle, N. J., & Peterson, E. R. (2004). Conceptions of learning and knowledge in higher education: Relationships with study behaviour and influences of learning environments. *International Journal of Educational Research*, 41, 407–428.

Gill, M. G., Ashton, P. T., & Algina, J. (2004). Changing preservice teachers' epistemological beliefs about teaching and learning in mathematics: An intervention study. *Contemporary Educational Psychology*, 29(2), 164–185.

Hammer, D., & Elby, A. (2002). On the form of a personal epistemology. In B. K. Hofer & P. R. Pintrich (Eds.), *Personal epistemology: The psychology of beliefs about knowledge and knowing*. Mahwah, NJ: Lawrence Erlbaum.

Hashweh, M. Z. (1996). Effects of science teachers' epistemological beliefs in teaching. *Journal of Research in Science Teaching*, 33(1), 47–63.

Hill, L. (2000). What does it take to change minds? Intellectual development of pre-service teachers. *Journal of Teacher Education*, 51(1), 50.

Hofer, B. K. (2000). Dimensionality and disciplinary differences in personal epistemology. *Contemporary Educational Psychology*, 25(4), 378–405.

Hofer, B. K. (2002). Personal epistemology as a psychological and educational construct: An introduction. In B. K. Hofer & P. R. Pintrich (Eds.), *Personal epistemology* (pp. 3–14). Mahwah, NJ: Lawrence Erlbaum.

Hofer, B. K. (2006). Domain specificity of personal epistemology: Resolved questions, persistent issues, new models. *International Journal of Educational Research*, 45, 85–95.

Hofer, B. K., & Pintrich, P. R. (1997). The development of epistemological theories: Beliefs about knowledge and knowing and their relation to learning. *Review of Educational Research*, 67(1), 88–140.

Hofstede, G. (1980). *Culture's consequences*. Beverly Hills, CA: Sage.

Hofstede, G., & Bond, M. H. (1988). The Confucius connection: From cultural roots to economic growth. *Organizational Dynamics*, 16(4), 4–22.

Jehng, J. -C. J., Johnson, S. D., & Anderson, R. C. (1993). Schooling and student's epistemological beliefs about learning. *Contemporary Educational Psychology*, 18(1), 23–35.

Johnston, P. H., Woodside-Jiron, H., & Day, J. (2001). Teaching and learning literate epistemologies. *Journal of Educational Psychology*, 93(1), 223–233.

Jonassen, D. H., & Grabowski, B. L. (1993). *Handbook of individual differences, learning, and instruction* (paperback edition). Mahwah, NJ: Lawrence Erlbaum.

Jonassen, D. H., Marra, R. M., & Palmer, B. (2004). Epistemolgical development: An implicit entailment of constructivist learning environments. In N. M. Seel & S. Dikjstra (Eds.), *Curriculum, plans and processes in instructional design: International perspectives* (pp. 75–88). Mahwah, N J: Lawrence Erlbaum.

Karabenick, S. A., & Moosa, S. (2005). Culture and personal epistemology: U.S. and Middle Eastern students' beliefs about scientific knowledge and knowing. *Social Psychology of Education*, 8, 375–393.

Kardash, C. M., & Howell, K. L. (2000). Effects of epistemological beliefs and topic-specific beliefs on undergraduates cognitive and strategic processing of dual-positional text. *Journal of Educational Psychology*, 92, 524–535.

King, P. M., & Kitchener, K. S. (1994). *Developing reflective judgment*. San Francisco, CA: Jossey-Bass.
Kloosterman, P., Raymond, A. M., & Emenaker, C. (1996). Students' beliefs about mathematics: A three-year study. *Elementary School Journal*, 97, 39–56.
Knefelkamp, L. (1974). *Developmental instruction: Fostering intellectual and personal growth in college students*. Unpublished Doctoral dissertation, University of Minnesota, Minneapolis-St. Paul.
Kuhn, D. (1999). A developmental model of critical thinking. *Educational Researcher*, 28(2), 16–26.
Limon, M. (2006). The domain generality-specificity of epistemological beliefs: A theoretical problem, a methodological problem or both? *International Journal of Educational Research*, 45, 7–27.
Lonka, K., & Lindbloom-Ylanne, S. (1996). Epistemologies, conceptions of learning and study practices in medicine and psychology. *Higher Education*, 31(1), 5–24.
Marra, R. M. (2005). The impact of the design of constructivist learning environments on faculty teaching epistemologies. *Learning Environments Research*, 8(2), 135–155.
Marra, R. M., & Palmer, B. (2005). University science students' epistemological orientations and nature of science indicators: how do they relate? *Science Education International*, 18(3), 165–184.
Marra, R. M., Palmer, B., & Litzinger, T. (2000). The effects of a first-year engineering design course on student intellectual development as measured by the Perry scheme. *Journal of Engineering Education*, 89(1), 39–45.
Mason, L., & Boscolo, P. (2004). Role of epistemological understanding and interest in interpreting a controversy and in topic-specific belief change. *Contemporary Educational Psychology*, 29, 103–128.
Moore, W. S. (1994). Student and faculty epistemology in the college classroom: The Perry schema of intellectual and ethical development. In K. W. Pritchard & R. M. Sawyer (Eds.), Handbook of college teaching: Theory and applications (pp. 45–67). westport, CT: Greenwood.
Moore, W. (1998). *The measure of intellectual development: An instrument manual*. Olympia, WA: Center for the Study of Intellectual Development.
Muis, K. R., Bendixon, L. D., & Haerle, F. C. (2006). Domain-generality and domain-specificity in personal epistemology research: Philosophical and empirical reflections in the development of a theoretical framework. *Educational Psychology Review*, 18(1), 3–54.
Palmer, B., & Marra, R. M. (2004). College student epistemological perspectives across knowledge domains: A proposed grounded theory. *Higher Education*, 37(3), 311–335.
Palmer, B., & Marra, R. M. (2006, November). *Liberal arts students' perceptions of knowledge domain epistemologies*. Paper presented at the Annual Meeting of the Association for the Study of Higher Education, Orange County, CA.
Pascarella, E. T., & Terenzini, P. T. (1991). *How college affects students*. San Francisco, CA: Jossey-Bass.
Paulsen, M. B., & Wells, C. T. (1998). Domain differences in the epistemological beliefs of college students. *Research in Higher Education*, 39(4), 365–384.
Perry, W. G. (1970). *Intellectual and ethical development in the college years: A scheme*. New York: Holt (Rinehart & Wiston).
Perry, W. G. (1981). Cognitive and ethical growth: The making of meaning. In A. Chickering et al.(Eds.), *The modern american college* (pp. 76–116). San Francisco, CA: Jossey-Bass.
Qian, G., & Alvermann, D. (1995). Role of epistemological beliefs and learned helplessness in secondary school students' learning science concepts from text. *Journal of Educational Psychology*, 87(2), 282–292.
Rosenberg, S., Hammer, D., & Phelan, J. (2006). Multiple epistemological coherences in an eighth-grade discussion of the rock cycle. *The Journal of the Learning Sciences*, 13(2), 261–292.
Roth, W. M., & Roychoudhury, A. (1994). Physics students' epistemologies and view about knowing and learning. *Journal of Research in Science Teaching*, 31, 5–30.
Ryder, J., & Leach, J. (1999). University science students' experiences of investigative project work and their images of science. *International Journal of Science Education*, 21(9), 945–956.

Ryder, J., Leach, J., & Driver, R. (1999). Undergraduate science students' images of science. *Journal of Research in Science Teaching*, 36(2), 201–219.

Schoenfeld, A. H. (1985). Students' beliefs about mathematics and their effects on mathematical performance: A questionnaire analysis (Publication no. ED259950) from Eric Document Service.

Schommer, M. (1993). Comparisons of beliefs about the nature of knowledge and learning among postsecondary students. *Research in Higher Education*, 34(3), 355–370.

Schommer, M. (1994). Synthesizing epistemological belief research: Tentative understandings and provocative confusions. *Educational Psychology Review*, 6(2), 293–319.

Schommer, M., Crouse, A., & Rhodes, N. (1992). Epistemological beliefs and mathematical text comprehension: Believing it is simple does not make it so. *Journal of Educational Psychology*, 6, 39–42.

Schraw, G., Bendixon, L. D., & Dunkle, M. E. (2002). Development and validation of the Epistemic Belief Inventory (EBI). In B. K. Hofer (Ed.), *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 261–275). Mahwah, NJ: Erlbaum.

Singelis, T. M., & Brown, W. J. (1995). Culture, self, and collectivist communication: Linking culture to individual behavior. *Human Communication Research*, 21(3), 354–389.

Slekar, T. D. (1998). Epistemological entanglements: Preservice elementary school teachers' "apprenticeship of observation" in the teaching of history. *Theory and Research in Social Education*, 26(4), 485–507.

Stephenson, B., & Hunt, C. (1977). Intellectual and ethical development: A dualistic curriculum intervention for college students. *Counseling Psychologist*, 6, 39–42.

Tasaki, K. (2001). *Culture and epistemology: An investigation of different patterns in epistemological beliefs across cultures*. Unpublished Doctoral, University of Hawaii.

Triandis, H. C. (1990). Cross-cultural studies of individualism and collectivism. In J. J. Berman (Ed.), *Nebraska symposium on motivation: Cross-cultural perspective* (Vol. 37, pp. 41–43). Lincoln, NE: University of Nebraska Press.

Triandis, H. C. (2001). Individualism-collectivism and personality. *Journal of Personality*, 69(907–924).

Tsai, C. C. (1998a). An analysis of scientific epistemological beliefs and learning orientations of Taiwanese eighth graders. *Science Education*, 82, 473–489.

Tsai, C. C. (1998b). An analysis of Taiwanese eighth graders' science achievement, scientific epistemological beliefs and cognitive structure outcomes after learning basic atomic theory. *International Journal of Science Education*, 20(4), 413–425.

Valanides, N., & Angeli, C. M. (2005). Effects of instruction on changes in epistemological beliefs. *Contemporary Educational Psychology*, 30(2), 314–330.

Westby, E., & Samarapungavan, A. (2001, April). *The relationship between increased methodological knowledge and epistemic beliefs: The role of instrumentation and techniques in Chemistry education*. Paper presented at the American Educational Research Association Annual Meeting, Seattle, WA.

White, B. (2000). Pre-service teachers' epistemology viewed through the perspectives on problematic classroom situations. *Journal of Education for Teaching*, 26(3).

Widick, C., Knefelkamp, L., & Parker, C. (1975). The counselor as developmental instructor. *Counselor Education and Supervision*, 14, 286–296.

Widick, C., & Simpson, D. (1978). Developmental concepts in college instruction. In C. Parker (Ed.), *Encouraging development in college students*. Minneapolis, MN: University of Minnesota Press.

Wineburg, S. S. (1991). Historical problem-solving: A study of the cognitive processes used in the evaluation of documentary evidence and pictorial evidence. *Journal of Educational Psychology*, 83(1), 73–87.

Youn, I. (2000). The culture specificity of epistemological beliefs about learning. *Asia-Pacific Journal of Social Psychology*, 3, 87–105.

Youn, I., Yang, K. M., & Choi, I. J. (2001). An analysis of the nature of epistemological beliefs: Investigating factors affecting the epistemological development of South Korean high school students. *Asia-Pacific Education Review*, 2(1), 10–21.

Zhang, L. F. (1999). A comparison of U.S. and Chinese university students' cognitive development: The cross-cultural applicability of Perry's theory. *The Journal of Psychology*, 133(4), 425–439.

Zhang, L. F., & Hood, A. B. (1998). Cognitive development of students in China and the USA: Opposite directions. *Psychological Reports*, 82, 1251–1263.

Zhang, L. F., & Watkins, D. (2001). Cognitive development and student approaches to learning: An investigation of Perry's theory with Chinese and U. S. university students. *Higher Education*, 41, 239–261.

Chapter 17
Personal Epistemology, Understanding of Multiple Texts, and Learning Within Internet Technologies

Ivar Bråten

Abstract Several studies have linked students' epistemological beliefs to their text-based learning, with this body of research generally indicating that more naive beliefs (e.g., that knowledge is certain or simple) are related to poorer performance. One limitation of these studies is that they have almost exclusively focused on the reading of one single text. Another, related, limitation is that learning has mainly been studied in traditional print environments. In the present chapter, I will address these two limitations of current epistemological research. First, I will argue that the importance of epistemological beliefs may be even greater when learners try to build integrated mental representations of multiple texts dealing with a particular topic than when they try to learn from one single text. Correspondingly, I will argue that epistemological beliefs may play a more important role in new technological learning environments than when learning with more traditional instructional materials. To empirically back up these arguments, I will then summarize and discuss the findings of some recent research conducted by my group at the University of Oslo, with this research pertaining to the role epistemological beliefs play in the understanding of multiple textual sources, as well as to their role when learning with hypermedia technology. Finally, some educational implications of these findings will be highlighted.

17.1 Introduction

Personal epistemology refers to beliefs and theories that individuals hold about knowledge and the process of knowing (Hofer & Pintrich, 1997). Much recent research on personal epistemology has continued Perry's (1970) early effort to identify developmental stages in students' epistemological thinking (e.g., Baxter Magolda, 1992; King & Kitchener, 1994), mostly through the use of interviewing methodology. However, those who now study personal epistemology within educational psychology owe particularly much to Marlene Schommer, who pioneered

University of Oslo, Oslo, Norway

M. S. Khine (ed.), *Knowing, Knowledge and Beliefs: Epistemological Studies across Diverse Cultures.*

the use of quantitative assessments to examine how epistemological beliefs are related to academic cognition and performance (Schommer, 1990).

According to Schommer (1990), personal epistemology could be described as a system of more or less independent beliefs, conceptualized as beliefs about the certainty, simplicity, and source of knowledge, as well as beliefs about the speed and control of knowledge acquisition. She also developed a 63-item questionnaire to assess this system, with this measure being used in much quantitative epistemological research following her seminal 1990 article. While the three first dimensions in Schommer's conceptualization fall under the more generally accepted definition of personal epistemology as beliefs about the nature of knowledge (certainty, simplicity) and knowing (source) (Hofer & Pintrich, 1997), the two last dimensions have been controversial because they mainly concern beliefs about learning (speed) and intelligence (control). Based on a thorough review of the literature, Hofer and Pintrich (1997) argued that personal epistemology should be defined more purely, with two dimensions concerning the nature of knowledge (what one believes knowledge is) and two dimensions concerning the nature or process of knowing (how one comes to know).

In this conceptualization, the dimensions *certainty of knowledge* and *simplicity of knowledge*, both concerning the nature of knowledge, correspond to the certainty and simplicity dimensions as described by Schommer (1990). The dimension certainty of knowledge ranges from the belief that knowledge is absolute and unchanging to the belief that knowledge is tentative and evolving, and the dimension of simple knowledge ranges from the belief that knowledge consists of an accumulation of more or less isolated facts to the belief that knowledge consists of highly interrelated concepts. Within the area of nature of knowing, the dimension *source of knowledge* ranges from the conception that knowledge originates outside the self and resides in external authority, from which it may be transmitted, to the conception that knowledge is actively constructed by the person in interaction with others. At least in part, this dimension parallels the source dimension as described by Schommer (1990). The final dimension in the Hofer and Pintrich (1997) conceptualization, *justification for knowing*, also concerns the nature of knowing, with this dimension referring to how persons justify or evaluate knowledge claims. This dimension ranges from justification through observation and authority, or on the basis of what feels right, to the use of rules of inquiry and the evaluation and integration of multiple sources. Justification for knowing seems to have no clear parallel within Schommer's (1990) belief system. In addition, Hofer and Pintrich (1997) considered both speed and control of knowledge acquisition to fall outside the construct of personal epistemology.

This chapter has two main goals related to personal epistemology. The first is to summarize our published research and work in progress concerning the effects of personal epistemology on the understanding of multiple texts. While several previous studies have linked personal epistemology to text-based learning and comprehension, those studies are almost exclusively focused on the reading of one single text. In the present chapter, I will address this limitation of existing epistemological research. First, I will argue that the importance of personal epistemology may be even greater when readers try to build integrated mental representations of multiple texts dealing with a particular topic than when they try to learn from one single text. Next, I will summarize findings from projects in which we examine the role played by personal epistemology in the understanding of multiple textual sources. Our published research on this issue has used a Norwegian version of the 63-item questionnaire that Schommer (1990) developed to assess her five-dimensional belief system. However, in an ongoing project, we have developed and used a topic-specific epistemological questionnaire based on the Hofer and Pintrich (1997) conceptualization (see above).

My second goal is to summarize our research on the relationship between personal epistemology and Internet-based learning activities. Thus far, the relations between personal epistemology and academic learning have mainly been studied in traditional print environments. In this chapter, I will also address this limitation by arguing that personal epistemology may play a more important role in new technological learning environments than when learning with more traditional instructional materials. To empirically back up this view, I will summarize our research pertaining to the role played by personal epistemology when students learn within Internet technologies. While some of this work has used Schommer's (1990) epistemological belief questionnaire, we have also developed and used an Internet-specific epistemological questionnaire based on Hofer and Pintrich's (1997) theoretical model of personal epistemology. I close with some educational implications of our work and a brief sketch of future research.

17.2 Current Research on Personal Epistemology and the Understanding of Multiple Texts

17.2.1 Understanding Multiple Texts

Learning from text still plays a major role in today's postindustrial information society, both in and out of school (Alexander & Jetton, 2000). Moreover, in today's society individuals are continually bombarded with information from innumerable, often conflicting information sources. At the same time, the need to make connections among multiple sources represents a great challenge to many readers. Within higher education, for example, students are frequently confronted with the complex task of linking multiple texts while reading, as the role of textbooks is often downplayed and primary and secondary source materials become more prominent. Still, many students seem to have little guided experience in learning from multiple textual sources, even at the college level.

To date, most research on the understanding of multiple texts has focused on the domain of history (e.g., Britt & Aglinskas, 2002; Britt & Sommer, 2004; Kurby et al., 2005; Rouet et al., 1996; Stahl et al., 1996; Wiley & Voss, 1999; Wineburg, 1991, 1998; Wolfe & Goldman, 2005), where the ability to build cumulative representations of historical events from the reading of a series of source documents may be regarded as the sine qua non of expertise (cf., Wineburg, 1998). In general, this research has established that the reading of multiple texts can be described as a challenging yet potentially beneficial activity, allowing readers to construct a deeper and more interconnected understanding of a topic than a single textbook-like source presenting the same content. According to Perfetti et al. (1995), the reading of multiple source documents in history also seems to help readers create more flexible representations of text information, with these representations being less tied to any specific text and more accessible under a variety of circumstances. This emphasis on flexibility particularly follows from the "cognitive flexibility theory" of Spiro and associates (e.g., Spiro et al., 1991, 1994), where gaining a rich and flexible understanding of a complex knowledge domain is said to require a "crisscrossing" of it from multiple intellectual perspectives. In this view, contrasting perspectives located in multiple sources may actually highlight the interrelated nature of knowledge and encourage readers to assemble knowledge components for application in new situations.

It should be noted that history is not the only domain that has been focused in research on the reading of multiple texts (e.g., see Bråten & Strømsø, 2003; Jacobson & Spiro, 1995; Kim & Millis, 2006; Strømsø & Bråten, 2002; Strømsø et al., 2003), and work on students' ability to integrate and use multiple textual sources could presumably be extended to any domain where students read multiple texts to gain principled knowledge, such as the humanities (e.g., philosophy) and the social sciences (e.g., psychology) (cf., Britt & Aglinskas, 2002).

The potential benefits of reading multiple texts on a topic may be explained within the theoretical framework of the construction–integration model of text comprehension (Kintsch, 1988), stressing the importance of integrating information provided by a single text with prior knowledge and other source materials to construct a situation model (cf., Strømsø et al., 2003; Wiley & Voss, 1999). Within the domain of history, Wineburg (1998) has termed such an intertextually based situation model an "event model," referring to the deeper understanding of a historical event that emerges from the integration of textual evidence and cognitive resources. Taking a somewhat different view, Rouet et al. (1996) suggested that learning from multiple texts may result in the interaction of several situation models, each based on a single text, with this resulting in an additional level of representation, an "argument" model, where both contents and sources of the multiple texts are represented. According to Britt et al. (1999), the understanding of multiple texts, at least by a good reader, involves building a "documents' model", that is, "a highly integrated situation model of the events learned, with only the most important events (i.e., core events) tagged for the source" (p. 221). Thus, in all these views, multiple text comprehension may involve a deep situational understanding of an event or a particular topic.

However, it seems highly unlikely that multiple texts would be equally beneficial for every reader. For example, cognitive flexibility theory suggests that exploring contrasting perspectives located in multiple sources will be more beneficial at relatively advanced stages of learning within a domain than at introductory level (Spiro et al., 1991, 1994). Accordingly, research indicates that high-school students hardly profit from the reading of multiple historical source documents, at least not without some specific instruction in how to integrate information across texts (e.g., Britt & Aglinskas, 2002; Wineburg, 1991). Some other researchers (Stahl et al., 1996; Strømsø & Bråten, 2002) have also highlighted the importance of prior knowledge in the domain for students who try to build an integrated understanding across multiple texts. But apart from the knowledge that the students possess about the topic of reading, the beliefs they hold about knowledge may enhance or constrain their ability to benefit from the reading of multiple texts about a particular topic.

17.2.2 Personal Epistemology and Text Comprehension

Schommer (1990) initially found that for students who read a passage in which the concluding paragraph was removed, the belief that knowledge acquisition is a speedy process that takes place quickly or not at all was related to the writing of oversimplified conclusions, poor performance on a comprehension test, and overconfidence in test performance. Moreover, belief in certain knowledge was related to inappropriate absolute conclusions. Later, several studies have linked personal epistemology to text comprehension (Kardash & Howell, 2000; Kardash & Scholes, 1996; Mason & Boscolo, 2004; Schommer et al., 1992; Schommer & Walker, 1995; Schommer-Aikins & Easter, 2004; Schraw et al., 2002), with this body of research generally indicating that more naive epistemological beliefs (e.g., that knowledge is certain and simple) are related to poorer comprehension performance.

In this area, the studies conducted by Gregory Schraw (2000; Schraw & Bruning, 1996) are unique because they have focused specifically on epistemologies of text, that is, on individuals' "epistemological assumptions about reading" (Schraw & Bruning, 1996, p. 292). For example, Schraw and Bruning (1996) focused on three kinds of epistemological assumptions that readers may bring to the reading task, comparing the view that meaning is actively constructed by the reader with the views that reading is passively receiving the author's meaning or translating the text's meaning in an objective manner. In brief, Schraw and Bruning (1996) found that for undergraduates reading a single text, viewing reading as active meaning construction positively affected personal engagement and comprehension, whereas viewing reading as receiving or translating meaning negatively affected them. Somewhat later, Schraw (2000) demonstrated that holding the belief that reading involves active meaning construction rather than transmission of meaning from author or text is positively related not only to a deeper processing of text content but also to the building of a more integrated understanding of the text (for an overview of findings, see Schraw & Bruning, 1999).

More recently, Mason et al. (2006) replicated Schraw's (2000) findings in samples of Italian middle and high school students, showing that readers' belief in active meaning construction may facilitate both deep-level text processing and the synthesizing or integration of textual ideas. At the same time, Mason et al. acknowledged that the effects of readers' beliefs on text processing and comprehension might have been larger had the students been given more than one reading text.

Research on the relationship between personal epistemology and text comprehension has so far been restricted to the comprehension of single texts. This may be considered a serious limitation because personal epistemology may be particularly important when students work on complex learning tasks (Hartley & Bendixen, 2001; Spiro et al., 1996). Given that the understanding of multiple texts can be described as a more complex task than the understanding of a single text (Wineburg, 1998), particularly in terms of constructive integration, relationships previously established between personal epistemology and single-text comprehension might be more pronounced when students read multiple texts. Accordingly, Stahl et al. (1996) suggested that the understanding of multiple texts seems to require a relatively sophisticated epistemological stance, where knowledge is seen as constructed through both rational processes and the melding of information from different perspectives. It also stands to reason that multiple texts may hamper rather than promote comprehension for readers who hold the naive beliefs that knowledge consists of unchanging, isolated bits of information handed down by authority rather than tentative, interrelated concepts constructed by the reader. Because multiple texts may be especially appropriate for constructing a situation model, it could also be assumed that readers holding naive epistemological beliefs would be particularly disadvantaged with respect to gaining a deeper understanding of text content. To address these issues empirically, our current and ongoing research concentrates on the effects of personal epistemology on different measures of text-processing strategies and comprehension when students read multiple texts about Attention-Deficit Hyperactivity Disorder (ADHD) and climate. I will now turn to a summary of this research.

17.2.3 Overview of Current Research

In this section, I overview our current research on personal epistemology and the understanding of multiple texts with respect to three questions. These questions address whether the text comprehension of readers holding naive and sophisticated epistemological beliefs could be differently affected by text format, whether any differences in multiple text comprehension could be associated with differences in strategic text processing, and whether topic-specific epistemological beliefs could moderate the relation between task instruction and intertextual comprehension.

17.2.3.1 Personal Epistemology and Text Format

The first question concerns whether the comprehension of readers that could be described as naive or sophisticated with respect to personal epistemology would be differently affected by text format, that is, by the reading of multiple texts versus the reading of one single text with identical content. In regard to this question, Bråten and Strømsø (2006a) hypothesized that for students holding sophisticated epistemological beliefs, the reading of multiple texts, compared with the reading of one single text with identical content, would be more beneficial. In contrast, students holding naive epistemological beliefs were expected to perform better when reading a single text about a particular topic than when reading multiple texts with identical content. Finally, it was hypothesized that the differential effect of text format for readers with naive and sophisticated epistemologies would manifest itself only on performance measures requiring deeper, situational understanding and not on measures of superficial understanding.

Bråten and Strømsø (2006a) selected 19 first-year teacher education students holding naive epistemological beliefs and 20 students holding sophisticated epistemological beliefs, based on their total score on the Schommer Epistemological Questionnaire (Schommer, 1998). One half of the participants in each of the two epistemology groups (i.e., naive and sophisticated) received seven separate texts about different aspects of ADHD, discussing this controversial issue from multiple perspectives. For example, one text of 362 words was a newspaper article presenting an interview with a researcher (physiologist), describing the genetic and neurobiological basis for ADHD and arguing for the importance of early and lifelong medication; another text was a 502-word feature article in a newspaper written by a psychologist, who argued against the increased use of medical/psychiatric diagnoses, such as ADHD, for "everyday" problems, criticized the pharmaceutical industry for promoting this viewpoint, and expressed concerns about the effects of labeling. The other half of the participants in each epistemology group received exactly the same content about ADHD, but it was presented as a textbook-like chapter (3,334 words).

Following Royer et al. (1996), Bråten and Strømsø (2006a) created a sentence verification task to measure participants' surface understanding of the text/s and an inference verification task to measure participants' deeper, situational understanding of the text/s. To test the hypotheses stated above, two separate 2 × 2 between-subjects analyses of covariance (ANCOVAs) were performed. In the first analysis, the sentence verification task was the dependent variable; in the second analysis, the inference verification task was the dependent variable. In each analysis, adjustment was made for three covariates: gender, word decoding, and prior knowledge about ADHD. Independent variables in each analysis were epistemological beliefs (naive and sophisticated) and text format (multiple texts and textbook chapter). In accordance with expectations, no statistically significant interaction between epistemological beliefs and text format appeared after adjustment by covariates when sentence verification was used as the dependent variable. However, when the inference verification task was used as the dependent measure, a statistically significant interaction between epistemological beliefs and text format was found. As can be seen in Fig. 17.1, the pattern of differences between text format conditions for the two epistemology groups was similar to the hypothesized pattern, with the reading of multiple texts facilitating deeper understanding among participants with sophisticated epistemological

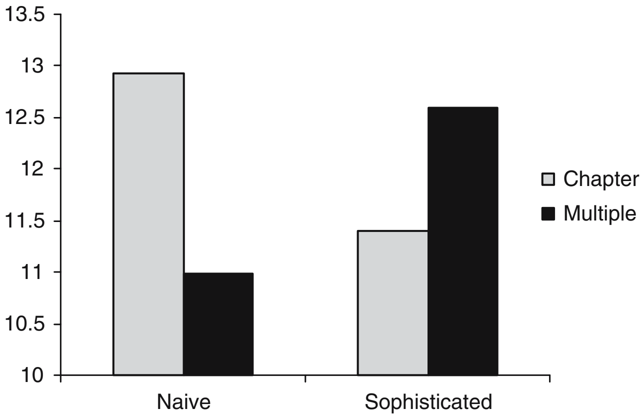


Fig. 17.1 Scores on the inference verification task showing interaction between epistemology group and text format after adjustment by gender, word decoding, and prior knowledge

beliefs, and with the reading of one textbook-like chapter most beneficial for participants with naive epistemological beliefs.

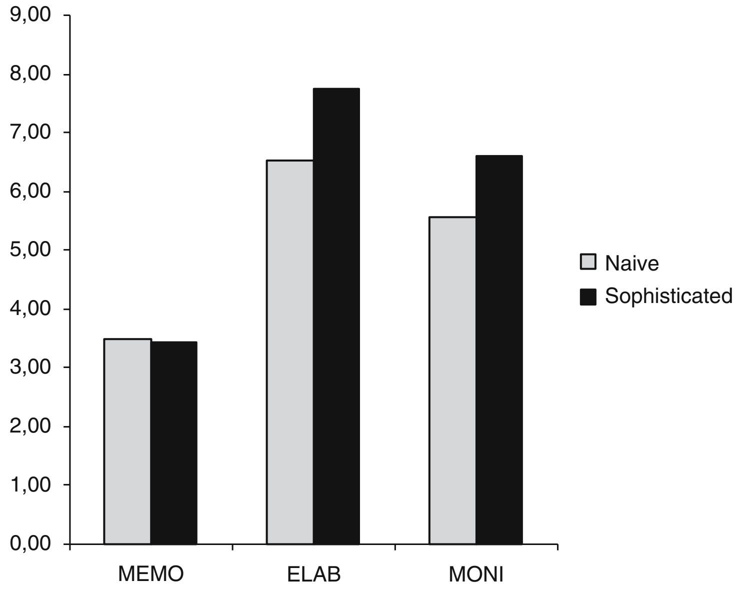
Thus, the Bråten and Strømsø (2006a) study provided new evidence concerning the relationship between epistemological beliefs, the reading of multiple texts, and text comprehension. The findings concerning deeper text comprehension supported the hypothesis that adult college readers are able to deal adequately with the challenge of integrating information from multiple, even conflicting, texts, provided that they hold relatively sophisticated beliefs about the nature of knowledge and knowledge acquisition. Otherwise, readers may be better off when encountering the same content in an integrated textbook format. The reason why students with naive epistemological beliefs seemed to do better on the inference verification task when presented with a textbook format than when presented with multiple texts might be that their tendency to view knowledge as true, simple facts handed down by authority made them particularly bewildered and frustrated in the multiple-texts situation, with this, in turn, interfering with their constructive processing of text. In comparison, students with sophisticated epistemological beliefs might have done more active inferential processing in the multiple-texts condition than the students with naive epistemological beliefs and, as a result of this, gained a deeper understanding of the texts because they actually believed that knowledge consists of complex, interrelated concepts constructed by the reader. This possibility is addressed by the second question.

17.2.3.2 Personal Epistemology and Strategic Text Processing

The second question concerns possible differences in the strategic text processing of readers holding naive and sophisticated epistemological beliefs when trying to understand multiple texts. To address this question, Bråten and Strømsø (2006b) examined whether students holding naive and sophisticated epistemological beliefs differed not only in regard to multiple text comprehension but also in regard to strategy use. There is much prior research documenting that the use of deeper-level strategies falling in the categories of elaboration and monitoring are linked to better remembering and understanding of text (for reviews, see National Reading Panel, 2000; Trabasso & Bouchard, 2002). While elaboration is used to make the content more meaningful by building connections between information given in the text and information located in other sources (e.g., associating to relevant prior knowledge or linking text content to other available material), monitoring involves readers assessing or regulating their comprehension (e.g., comprehension confirmation, problem detection, and problem solving) (Bråten & Strømsø, 2003). Presumably, the use of deeper-level strategies such as elaboration and monitoring will be particularly important when students try to build an integrated understanding across multiple texts. In line with this, Strømsø et al. (2003) observed that elaboration and monitoring were more involved in the construction of an integrated situation model during multiple text reading than were other types of strategies (i.e., memorization and organization). However, Bråten and Strømsø (2006b) asked whether personal epistemology might constrain or increase readers' use of effective text-processing strategies when dealing with multiple sources.

Bråten and Strømsø (2006b) compared groups of undergraduate students holding naive and sophisticated epistemological beliefs according to their total scores on the Schommer Epistemological Questionnaire. In both groups, all students read the seven separate texts about ADHD described above and afterward answered sentence and inference verification tasks about text content. However, immediately after the students had finished reading the texts (and before answering the verification tasks), they were asked to mark a strategy use inventory. The inventory included three scales focusing on memorization, elaboration, and monitoring, respectively. Each item of the strategy use inventory referred to the recently completed reading task as a frame of reference and was accompanied by a 10-point Likert-type scale, on which the participants rated to what extent the statement described what they had been just doing while studying the texts. Bråten and Samuelstuen (2004; Samuelstuen & Bråten, 2005) have shown construct validity of students' self-reports on this strategy inventory, both through factor analyses and relations between strategy scores and learning outcomes (see also, Samuelstuen & Bråten, 2007).

Bråten and Strømsø (2006b) found that readers holding sophisticated epistemological beliefs clearly outperformed readers holding naive epistemological beliefs on both the sentence and the inference verification tasks. Thus, students differing in terms of epistemological beliefs were found to differ with respect to superficial understanding as well as with respect to deeper, situational understanding. When Bråten and Strømsø (2006b) compared the scores of the two epistemology groups on each of the three strategy scales, they observed that there was no difference between sophisticated and naive participants with respect to memorization. However, as expected, participants holding sophisticated epistemological beliefs reportedly used elaboration more during reading than students holding naive epistemological beliefs. As can be seen in Fig. 17.2, the results also showed a



Note. Memo = Memorization, Elab = Elaboration, Moni = Monitoring.

Fig. 17.2 Scores on text-processing strategy measures for readers with naive and sophisticated epistemological beliefs

difference in the favor of students holding sophisticated epistemological beliefs with respect to monitoring.

Thus, the results concerning strategic processing seemed to be consistent with the hypothesis that differences between the two epistemology groups with respect to multiple text comprehension, at least in part, could be explained by readers with sophisticated epistemological beliefs engaging more in deep level processing in the form of elaboration and monitoring. Effect size estimations indicated that the differences in regard to elaboration and monitoring strategies could be described as moderately large.

17.2.3.3 Personal Epistemology and Reading Task

The third question concerns whether the effect of task instruction on multiple text comprehension may be moderated by personal epistemology. Most empirical support for the idea that students' text processing is influenced by the reading task is based on single-text studies contrasting the very distinctive tasks of reading in preparation for an examination and reading for entertainment (Linderholm & van den Broek, 2002; Narvaez et al., 1999; van den Broek et al., 2001). However, some studies have also shown that students may alter their text processing in accordance with different study-related reading tasks. For example, Bråten and Samuelstuen (2004) found that tenth-grade students instructed to read in order to prepare for a test, write a summary, or discuss text content with peers, adjusted their text processing accordingly, also showing that the effect of reading task on text processing may depend on students' prior knowledge about the topic of the text. Recently, Mason et al. (2006) compared generic and specific task instructions for writing comments on the reading text, finding that students who received specific instructions for writing comments displayed a more integrated understanding of the text than those receiving generic instructions. However, no interaction between task instructions and epistemological beliefs about reading emerged in the Mason et al. (2006) study.

In one of the few studies exploring the relationship between reading task and multiple text reading, Bråten and Strømsø (2003) found that when law students reading self-selected study texts changed their understanding of the reading task from reading to keep up with lectures to reviewing for the examination, they also adjusted their text processing to fit the new reading task. When Wiley and Voss (1999) had undergraduates read multiple documents about a historical event under the different task conditions of writing an argumentative essay, a narrative, a summary, or an explanation, it was found that students who read in order to write arguments gained more integrated and deeper understandings of the topic than did the students who read the same documents in the other three task contexts. Sometimes, students read multiple texts to answer certain questions. In such cases, it is not unimportant how those questions are formulated. Recently, Raquel Cerdán and Eduardo Vidal-Abarca (in press) showed that relatively broad questions may facilitate text integration and prevent readers from concentrating on isolated bits of information. Very narrow questions, on the other hand, may occasion that readers search for, find, memorize, and reproduce isolated bits of information, which may be sufficient for answering the narrow questions correctly but hamper rather than facilitate a deeper understanding of the texts' content. Also, Britt and Sommer (2004) found that the extent to which readers formed an integrated representation when reading two texts about a historical event was influenced both by task instructions given before reading and by intervening tasks, with instructions to integrate and intervening tasks in the form of macro-level summary writing and macro-level question answering seemingly facilitating multiple text comprehension.

On this background, it seems important to investigate further how different task conditions may be related to differences in the processing and comprehension of multiple texts. Moreover, the possibility that the effect of task on multiple text understanding could be moderated by personal epistemology should be explored.

In an ongoing project, Bråten et al. (2007) had 227 undergraduate education students read seven different, partly conflicting texts about climate (global warming) under three different task conditions: (1) to produce an elaborative summary of the most relevant information in the texts (elaborative summary task),(2) to express and justify their personal opinion on the topic of the texts (argumentation task), or (3) to impart a global understanding of the issues discussed in the texts (global understanding task). The participants were also divided into naive and sophisticated with respect to dimensions of topic-specific epistemological beliefs, with those dimensions emerging after factor analysis of an epistemological belief questionnaire concerning beliefs about knowledge about climate and how one comes to know about climate. Bråten et al. (2007) performed a 2 × 3 between-subjects analysis of covariance (ANCOVA). In this analysis, adjustment was made for four covariates: gender, age, word decoding, and prior knowledge. Independent variables were personal epistemology (naive and sophisticated) and task (elaborative summary, argumentation, and global understanding). The two epistemology groups (naive and sophisticated) were formed according to participants' certainty beliefs. The dependent variable was an inference verification task especially designed to measure students' ability to draw inferences across texts.

The ANCOVA showed that, after adjustment by covariates, there was a statistically significant main effect of task on intertextual understanding. However, this effect was moderated by students' certainty beliefs, as shown by a statistically significant interaction between task and certainty beliefs. The nature of this interaction is displayed in Fig. 17.3.

As can be seen in Fig. 17.3, the most salient components of the interaction were (a) better intertextual understanding for the participants holding sophisticated certainty beliefs than for the participants holding naive certainty beliefs on the argumentation task, (b) better intertextual understanding for the participants holding sophisticated certainty beliefs on the elaborative summary and argumentation tasks than on the global understanding task, and (c) poorer intertextual understanding for the participants holding sophisticated certainty beliefs than for those holding naive certainty beliefs on the global understanding task.

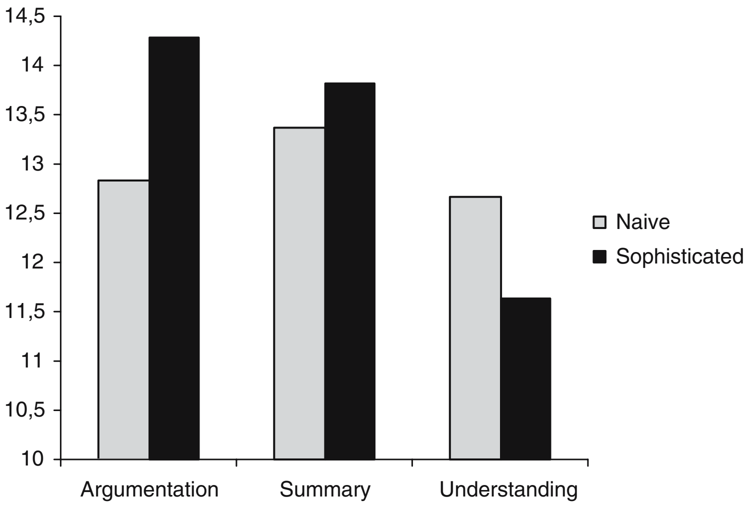


Fig. 17.3 Scores on the intertextual comprehension measure showing an interaction between certainty beliefs and task instruction after adjustment by gender, age, word decoding, and prior knowledge

Thus, compared to readers holding naive epistemological beliefs, those holding sophisticated beliefs may particularly profit from the challenging task of expressing and justifying their personal opinion, whereas their intertextual understanding may be hindered when given the very broad task of constructing a global, overall understanding of the topic. Under the last condition, readers with sophisticated epistemological beliefs actually seem to deteriorate so much that they may be outperformed by readers holding naive beliefs. While the reason for this deterioration is not perfectly clear, one possible explanation is that when reading these complex expository texts on a complex topic, students characterized by more mature epistemological thinking more readily realize that this very broad task is unmanageable and impracticable given the circumstances, with this, in turn, leading to feelings of resignation and frustration and distracting from their constructive processing of text content. One of our next steps in this ongoing research will be to examine the strategic text processing of readers differing with respect to personal epistemology under different task conditions.

17.3 Current Research on Personal Epistemology and Learning Within Internet Technologies

In the research that was summarized in the previous section, we presented the documents in the form of traditional print-based texts. However, in present-day society, both in and out of school, readers increasingly encounter information provided through hypermedia technology, such as the Internet. Still, there is some obvious similarity between the multiple text conditions of our described experiments and what characterizes the reading of online sources. First, the texts that we provided represented different types of documents expressing diverse viewpoints on a topic, and they were read in a self-selected order. Second, it was the task of the readers themselves to determine the evidentiary value of the documents and build an integrated understanding across texts. At the same time, however, Internet technologies seem to represent additional challenges to readers. For example, reader comprehension may be difficult because so much is demanded in terms of controlling the relevance and accuracy of Internet-based sources (Leu, 2000). This may be particularly difficult for students because they often develop a blind trust in the textbooks that they use in their classrooms (Paxton, 1999). Moreover, readers may become cognitively overwhelmed by trivia and seductive details that distract from important information and impede knowledge construction (Meyer & Rose, 1998). Presumably, the main question is not whether Internet-based learning environments are good for learners or not, but rather what learner characteristics are required to succeed in those environments.

Hartley and Bendixen (2001) argued that students' personal epistemology might be particularly relevant to learning in new technological environments.

This is because students in such environments typically have more control over instruction, and they often search and evaluate information at their own discretion, allowing for individual differences to shape how the technology is used. Thus, there is some reason to expect that students who seem to become handicapped by their naive epistemological beliefs when reading multiple texts on paper, might become even more so when learning with hypermedia technology, such as the Internet.

So far, there exists only limited empirical evidence for the suggested link between personal epistemology and learning with hypermedia technology. However, Jacobson and Spiro (1995) provided some preliminary evidence that students who believed in simple knowledge had problems handling the nonlinear and multidimensional nature of an ill-defined hypertext system.

Some time later, Bendixen and Hartley (2003) measured the five epistemological dimensions included in Schommer's (1990) conceptualization and found three of them to predict achievement in a hypermedia-learning environment. Specifically, naive beliefs about the source of knowledge (i.e., knowledge is handed down by authority) and the control of knowledge acquisition (i.e., ability to learn is given at birth) were related to poorer performance, whereas naive beliefs about the speed of knowledge acquisition (i.e., learning takes place quickly or not at all) were related to better performance. When Hartley and Bendixen (2003) examined whether Schommer's (1990) five epistemological dimensions were related to students' use of comprehension aids (e.g., advanced organizers and self-test questions) and their navigation through the content of the hypermedia tutorial, they found that naive beliefs about the source of knowledge were negatively related to nonlinear progression through the content. However, the more naive beliefs students held about the speed of knowledge acquisition, the more use they made of the comprehension aids provided by the system. To explain this latter finding, Hartley and Bendixen (2003) suggested that students who believed learning to take place quickly or not at all might have used available comprehension aids in lieu of studying the materials included in the hypermedia tutorial more thoroughly.

Using another type of methodology, Hofer (2004) reported that students who thought aloud during online searching expressed all the four kinds of epistemological beliefs included in the Hofer and Pintrich (1997) model. Additionally, Hofer (2004) reported that students expressing naive epistemological beliefs were likely to pursue the searching task in a brief and perfunctory way, not seeing the need for additional sources or reflecting on the credibility and accuracy of the sources they located.

Thus, while a few recent studies have suggested that personal epistemology may be linked to students' learning within hypermedia and Internet technologies, there seems to be a clear need to examine the relationship between personal epistemology and Internet-based learning activities further. In our current research, we relate measures of different epistemological dimensions to measures of students' use of informational Internet resources and their use of the Internet for communication and discussion about subject content. In the two following sections, I will summarize our work on this issue.

17.3.1 Epistemological Beliefs Predict Internet-based Learning Activities

In a longitudinal study with teacher education students, Bråten and Strømsø (2006c) examined whether students' epistemological beliefs measured in the autumn term of their first year of study could predict their Internet-based learning activities measured in the autumn term of the second year. In the first year, Bråten and Strømsø (2006c) used scales measuring two dimensions of personal epistemology emerging after factor analysis of the Schommer Epistemological Questionnaire (Bråten & Strømsø, 2005). The measure of students' *beliefs about the speed of knowledge acquisition* included items focused on the time it takes for learning to occur. This dimension ranged from the belief that learning occurs quickly or not at all to the belief that learning is a gradual process requiring both time and effort. The measure of students' *beliefs about knowledge construction and modification* consisted of items dealing with the idea that knowledge is constructed and modified through the identification of new ideas, the use of learning-to-learn skills, the integration of information from multiple sources, critical processing, and the recognition that existing knowledge is only tentative. This dimension ranged from the view that knowledge is given and stable to the view that knowledge is actively constructed and constantly evolving. To assess students' learning activities when performing search tasks on the Internet, Bråten and Strømsø (2006c) asked them to rate statements pertaining to identification of relevant information and evaluation of the appropriateness of information. Additionally, students' reported use of the Internet for communication and discussion about subject content was assessed.

Bråten and Strømsø (2006c) computed two regression equations with students' reported Internet-search activities and Internet-communication activities, respectively, as outcome measures. The predictors for each of those equations were the two first-year epistemological belief measures as well as a measure of students' individual interest. In addition, the dichotomous variable of gender was included for a total of four predictors for each equation. In this context, however, I will concentrate on the predictability of the epistemological belief measures.

First, the regression of the Internet-search measure indicated that beliefs about the speed of knowledge acquisition were a statistically significant predictor, with students who believed learning to take place quickly or not at all more likely to report that they proficiently performed such tasks on the Internet. Second, beliefs about knowledge construction and modification were a statistically significant predictor of Internet-communication activities, with students who held naive epistemological beliefs about the nature of knowledge reportedly less likely to use the Internet for study-related communication purposes.

Thus, the findings of Bråten and Strømsø (2006c) indicated that students' beliefs about the speed of knowledge acquisition may have implications for their performance on search tasks on the Internet. Specifically, students who believed that learning occurs quickly or not at all were more likely to consider information search and evaluation unproblematic than students who believed learning to be a gradual process requiring both time and effort. Presumably, when students believe that more time and effort do not coincide with more learning, they may consider it a waste of time to search for additional information and dwell unnecessarily on the information they have located. However, managing the wealth of information found on the Internet and critically evaluating Web-based resources is not quickly or easily done (Rouet, 2006). That students who believe in quick learning do not seem to realize the great challenge involved in this enterprise may actually impede their development toward becoming efficient searchers in complex computerized information systems. Moreover, Bråten and Strømsø's (2006c) findings suggested that students' beliefs about knowledge construction and modification may play a role for their participation in online communication and discussion about subject content. Specifically, it was found that students who conceived of knowledge as given and stable were less likely to take advantage of the opportunity for Internet-mediated communication offered by the learning environment in which they studied. The reason for this might be that students who believe in given and stable knowledge do not see the point of participating in mutual negotiations, perhaps involving multiple conflicting interpretations, about the meaning of subject content. However, as we shall see in the next section, students' naive epistemological beliefs may also be related to more self-reported participation in Internet-based communication activities.

17.3.2 Research on Internet-Specific Epistemological Beliefs

Bråten et al. (2005) extended existing research on personal epistemology and learning within Internet technologies considerably by constructing a measure that specifically focused on epistemological beliefs about Internet-based knowledge and knowing. Furthermore, they sought to ascertain whether such Internet-specific epistemological beliefs could be used to predict aspects of students' online learning.

One limitation of existing survey research on personal epistemology and Internet-based learning concerns the use of epistemological belief measures not specifically targeting Web-based knowledge or the process of knowing when utilizing Web-based resources. Instead, domain-general measures of epistemological beliefs that focus on conventional-print environments have been used. However, because hypermedia technologies such as the Internet allow for new ways of presenting knowledge and new ways of knowing, measures of personal epistemology should probably focus specifically on beliefs about the nature of knowledge and knowing in such technological environments. Bråten et al. (2005) therefore developed an instrument to assess students' beliefs about Internet-based knowledge (i.e., what they believe knowledge is like on the Internet) and knowing (i.e., how they come to know on the Internet) more specifically. The resulting 36-item Internet-Specific Epistemological Questionnaire (ISEQ) was based on Hofer and Pintrich's (1997) theoretical model of personal epistemology. Thus, items were written to assess two hypothesized dimensions concerning Internet-based knowledge and two hypothesized dimensions concerning Internet-based knowing, with the two dimensions concerning Internet-based knowledge labeled *certainty of Internet-based knowledge* and *simplicity of Internet-based knowledge*, respectively, and the two dimensions concerning Internet-based knowing labeled *source of knowledge* and *justification for knowing*, respectively (A parallel English version of the ISEQ has also been developed; Bråten & Weinstein, 2004).

Bråten et al. (2005) administered the ISEQ to political science undergraduates to empirically examine the dimensionality of Internet-specific epistemological beliefs. Using exploratory as well as confirmatory factor analyses, they identified two dimensions which they labelled General Internet Epistemology and Justification for Knowing, respectively. The first dimension, General Internet Epistemology, concerned beliefs about the certainty and simplicity of Internet-based knowledge, as well as beliefs about the Internet as a source of knowledge. This dimension ranged from the view that the Internet is an essential source of certain (i.e., true, accurate) and simple (i.e., detailed, factual) knowledge about course-related content to doubt about the Internet as a good knowledge source that can provide certain knowledge about specific facts. The second dimension, Justification for Knowing, concerned the critical evaluation of knowledge claims encountered on the Internet through the use of multiple sources, reasoning, and prior knowledge activation. This dimension ranged from the idea that Internet-based knowledge claims can be accepted without critical evaluation to the view that such knowledge claims need to be checked against other sources, reason, and prior knowledge about subject content. Thus, although several dimensions of Internet-specific epistemological beliefs can be distinguished conceptually, in accordance with Hofer and Pintrich's (1997) general model, the dimensions seemed to be less distinguishable empirically, with beliefs concerning the certainty, simplicity, and source of knowledge forming a coherent way of thinking about Internet-based knowledge and knowing. The fact that beliefs concerning the justification for knowing appeared as a separate dimension in the factor analyses, suggests that Internet-specific epistemological beliefs may be neither a multidimensional nor a one-dimensional construct, instead suggesting a two-dimensional model of such beliefs.

Bråten et al. (2005) also ran four hierarchical multiple regression analyses to examine the contribution of Internet-specific epistemological beliefs to Internet-based learning activities. Based on factor analysis of a 22-item self-report questionnaire concerning online learning, four measures capturing different types of Internet-based learning activities were constructed. The first measure, Internet Search – Identification and Evaluation, focused on the identification of relevant information and the evaluation of the appropriateness of information, with high scores on this measure indicating that students were reportedly competent in conducting searches and evaluating search results and low scores indicating that they found the identification and evaluation of Internet-based sources problematic. The second measure, Internet Search – Use of Relevant Information, focused on students' use of the information they had located on the Internet in their coursework, with high scores representing reports of high competence in using Internet-based sources to understand the course material and low scores indicating that students found it problematic to draw on Internet-based sources when doing coursework. The third measure, Internet Communication – Guidance, Cooperation, and Discussion, concerned use of the Internet for expert guidance, as well as for cooperation with other students when working on assignments and discussion of course-related issues. High scores on this measure reflected high levels of course-related Internet-based communication with both teachers and other students and low scores indicated low participation in such Internet-based communication activities. Finally, the fourth measure of Internet-based learning activities, Internet Communication – Preference for Internet-based Feedback and Discussion, concerned the degree to which students preferred to receive feedback and make contributions online rather than in face-to-face encounters, with high scores indicating preference for online feedback and contributions and low scores indicating preference for face-to-face discussions.

The four measures of Internet-based learning activities described above were used as dependent measures in the four hierarchical multiple regression analyses. In each analysis, variance associated with gender, age, and experience with using information and communication technologies (ICT) was removed in step 1. In step 2, scores on the two measures of Internet-specific epistemological beliefs that resulted from the factor analyses were entered into the equation, together with scores on a measure of Internet self-efficacy. In brief, Bråten at al. (2005) found that students' general Internet epistemology predicted all four types of Internet-based learning activities, even after variance from the variables gender, age, and ICT use had been partialled out. However, the justification for knowing dimension predicted only Internet communication – preference for Internet-based feedback and discussion. In addition, Internet-based learning activities were stronger and more consistently predicted by epistemology than by Internet self-efficacy.

In all analyses conducted by Bråten et al. (2005), more naive epistemological beliefs were related to higher scores on the measures of Internet-based learning activities. First, this means that students holding the belief that the Internet is an essential source of accurate, specific facts about what they are studying were reportedly more skilled in searching the Internet for relevant information and using the information they located when doing their coursework. Again, given the great challenge involved in searching for and using information located on the Internet (Rouet, 2006), this relationship may suggest that the more naive beliefs students hold about Internet-based knowledge and knowing, the more naive they may be about the ease with which relevant Internet-based sources can be identified and used (see also, Hofer, 2004). Second, this means that students who viewed the Internet as an essential knowledge source providing them with true knowledge in the form of specific facts, were reportedly more likely to participate in

Internet-based communication with teachers and other students as well as to prefer Internet-based communication to face-to-face discussion. Moreover, students who believed that Internet-based knowledge claims could be accepted without critical evaluation seemed more likely to prefer online communication to face-to-face discussion. As discussed by Bråten et al. (2003), attempts to promote collaborative learning through the use of ICT are not always met with success. For example, the activity level of students seems to vary a lot, the teacher is often the most active participant, and discussions between students tend to die out rather quickly. According to Bereiter and Scardamalia (2000), this is the "dirty little secret" of many ICT-based learning environments. Taking into consideration the great challenges and complexities involved in high-quality collaborative learning within Internet technologies (Bråten et al., 2003), it seems plausible that students holding naive epistemological beliefs about Internet-based knowledge and knowing may actually display an overreliance on the Internet as a communication tool, perhaps resorting to Internet-based communication as much for convenience as for meaningful learning experiences and overestimating the value of virtual exchanges at the expense of real-life encounters. It should be noted that these interpretations of our findings regarding personal epistemology and learning within Internet technologies, despite the observation that naive epistemological beliefs were positively related to self-reported Internet-based learning activities, are consistent with research in traditional print environments demonstrating the disadvantage of holding naive beliefs about knowledge and knowing. However, a firmer underpinning for these interpretations of our findings must await further research where self-reports of Internet-based learning activities are replaced or supplemented with more direct observations or registrations of such activities.

In closing this section, I optimistically foresee that our current studies may initiate an important line of research on personal epistemology and learning in new technological environments. Recently, Alexander (2004) rhetorically asked: "Where is the extensive body of work on the processes of learning in a hypermedia environment?" (p. 152) Of course, Alexander's question implies a challenge to conduct systematic research on a wide range of technological, psychological, and instructional issues. Still, I remain enthusiastic about the outcomes of our current research on personal epistemology and learning within Internet technologies because of the implications it affords not only for theory but also for educational practice.

17.4 Educational Implications

According to Britt et al. (1999), readers who are able to construct an integrated understanding from multiple texts may still take note of some of the specific sources, at least for the most important events or ideas described in the texts. Clearly, this ability is one that needs to be trained, as many students seem to have received surprisingly little instruction in how to handle multiple texts, given the abundance of information sources in present-day classrooms. Moreover, our findings suggest that the need for some specific training in integrating information from multiple texts may be greater among students holding naive beliefs about knowledge and knowing.

To address this instructional challenge, Britt and Aglinskas (2002) developed the "Sourcer's Apprentice," a computer application teaching the integration of separate texts when researching a historical controversy. In this approach, students are presented with a set of different documents about each controversy, varying in type from textbook excerpts to primary documents, which they read in a self-selected order. While reading each document, they fill in a note card with information about the author (who, position, how know, and motives), document (when, type), and content (other documents mentioned, main point, comments). When the student thinks that he or she has studied the documents enough, the student answers a series of questions about the content and sources of the documents. Finally, the student writes an essay about the controversy, with only the note cards available during writing. Britt and Aglinskas (2002) showed that students who used the Sourcer's Apprentice in place of an integrated single-text presentation of the same content wrote essays on the controversy that were more integrated, cited more sources, and referenced more information from primary and secondary sources than did the comparison group.

It seems that a tutoring system such as the Sourcer's Apprentice could easily be adapted to other domains than history. However, in light of research described in this chapter, I would suggest that such a tool becomes coupled with instruction that helps students reflect on and, if necessary, change the epistemological beliefs that may affect their ability to understand multiple texts. The point is that some students may need specific guidance in developing epistemological beliefs that are more congruent with adaptive learning from multiple information sources because epistemological beliefs do not necessarily change with education without being targeted directly (Bråten & Olaussen, 2005). While much remains to be known about how to approach this instructional challenge, preliminary evidence indicates that instruction to promote changes in epistemological beliefs can be effective. For example, having students struggle to understand complex issues by reading texts presenting them with multiple perspectives on a topic, integrated with discussions of both text content and their current epistemological thinking, may bring about belief change (cf., Schraw & Sinatra, 2004). Recently, Valanides and Angeli (2005) observed that students who read a text presenting opposing views on a controversial topic ("Are American values shaped by the mass media?") and then discussed the text content, reflected on their thinking about the issue, and evaluated their thinking in light of principles for critical thinking, developed more mature epistemological beliefs after the intervention. Accordingly, the reading of multiple texts containing contrasting perspectives on a topic might be a particularly good starting point for explicit, shared reflection on both content and epistemological beliefs in relation to that content, with such reading and concomitant collective reflection presumably having the potential to foster the belief revisions that many students seem to need.

Because students' personal epistemology, according to our findings, may be linked to their strategic competence in handling multiple texts, multiple text comprehension should also be promoted by instruction in deeper-level strategies. Within the framework of Concept-Oriented Reading Instruction, Guthrie et al. (2004) have shown that long-term comprehension instruction in the classroom, emphasizing motivated strategy use, may indeed promote the comprehension of multiple texts. In that study, students read multiple texts of different types about a particular topic (ecology) and were taught the strategies of activating background knowledge, questioning, searching for information, summarizing, organizing graphically, and identifying story structure, with this resulting in much better multiple text comprehension as assessed through essay writing than that of a comparison group. At the same time, such sophisticated, deep-level processing of text content probably contributes to the fostering of epistemological belief revision (Schraw & Sinatra, 2004; Valanides & Angeli, 2005).

Given the naive beliefs that some students seem to hold about Internet-based knowledge and knowing, as well as the uncritical attitudes and superficial approaches to learning within Internet technologies that those beliefs seem to foster, it could be argued that the role of Internet technologies in education should be reduced. Another possibility might be to try to give students holding naive epistemological beliefs a more structured experience when working with electronic documents. For example, these students might do better if their options for searching and using information were somewhat restricted, as when electronic documents contain only relevant and not simply available hyperlinks and they are guided to read those links in a predetermined way (cf., Kim & Kamil, 2003). Also, students might be instructed to read the entire text before pursuing any hyperlinks. However, it could be countered that the ability to search, use, and share Web-based resources is a necessity not only for educational success but also for full inclusion in society and economic life. Therefore, rather than taking on the impossible task of trying to protect some students from those resources, education should probably try to make them better equipped to reap the potential benefits of current Internet technologies. Because many issues concerning Internet-based learning may be issues of personal epistemology at least as much as they are issues of technology (Hofer, 2004), advanced Internet literacy can probably not be promoted by instruction targeting technological skills alone. In addition, students may need help reflecting on and changing too naive beliefs about Internet-based knowledge and knowing. In connection with pedagogical use of the Internet, it may thus be an important task for teachers to try to nudge students into thinking and reflecting about epistemological beliefs and how those beliefs may relate to online information processing and learning. Of course, this demands that teachers also develop their own epistemological thinking and come to see how their beliefs and those of the students affect learning and comprehension.

17.5 Future Research

I conclude this chapter with some future research goals. One of those is to further examine the effects of topic-specific epistemological beliefs on multiple text comprehension. Students' ability to profit from the reading of multiple sources about a particular topic is probably more strongly affected by their epistemological thinking about that specific topic than by their more general beliefs. Identifying truly topic-specific epistemological beliefs in valid and reliable ways is therefore essential to the success of our ongoing research. Likewise, further research with the Internet-Specific Epistemological Questionnaire should probably adapt the items of the instrument to reflect the specific topic of students' Internet-based learning endeavors.

A second goal is to examine more closely the strategic processing of multiple information sources by using alternatives to self-report measures, for example, think-aloud protocols or trace methodologies. A particular challenge for this research will be to obtain valid measurements of learners' intertextual linking strategies and relate those measurements to both personal epistemology and multiple text comprehension.

A third goal is to study how topic-specific epistemological beliefs, intertextual linking strategies, and the understanding of multiple information sources, as well as relations among those processes, develop over time and change with educational level. Related to this future research goal is the need to gain a better understanding of how those processes may be changed via instruction at different educational levels.

A fourth goal is to try to grasp the differences and similarities between epistemological thinking, strategic processing, and intertextual understanding in conventional print environments and new technological environments. As these processes may vary in yet unknown ways with the kind of source materials (i.e., printed versus digital) that learners use, extrapolations based on research conducted in only one type of learning environment may be problematic. Indeed, the study of personal epistemology, understanding of multiple texts, and learning within Internet technologies is still in its infancy.

References

Alexander, P. A. (2004). In the year 2020: Envisioning the possibilities for educational psychology. *Educational Psychologist*, 39, 149–156.

Alexander, P. A., & Jetton, T. L. (2000). Learning from text: A multidimensional and developmental perspective. In M. L. Kamil, P. B. Mosenthal, P. D. Pearson, & R. Barr (Eds.), *Handbook of reading research* (Vol. 3, pp. 285–310). Mahwah, NJ: Erlbaum.

Baxter Magolda, M. B. (1992). *Knowing and reasoning in college: Gender-related patterns in students' intellectual development*. San Francisco, CA: Jossey-Bass.

Bendixen, L. D., & Hartley, K. (2003). Successful learning with hypermedia: The role of epistemological beliefs and metacognitive awareness. *Journal of Educational Computing Research*, 28, 15–30.

Bereiter, C., & Scardamalia, M. (2000). Commentary on part 1: Process and product in problem-based learning (PBL) research. In D. H. Evensen & C. E. Hmelo (Eds.), *Problem-based learning: A research perspective on learning interactions* (pp. 185–195). Mahwah, NJ: Erlbaum.

Britt, M. A., & Aglinskas, C. (2002). Improving students' ability to identify and use source information. *Cognition and Instruction*, 20, 485–522.

Britt, M. A., & Sommer, J. (2004). Facilitating textual integration with macro-structure focusing tasks. *Reading Psychology*, 25, 313–339.

Britt, M. A., Perfetti, C. A., Sandak, R., & Rouet, J. F. (1999). Content integration and source separation in learning from multiple texts. In S. R. Goldman, A. C. Graesser, & P. van den Broek (Eds.), *Narrative, comprehension, causality, and coherence: Essays in honor of Tom Trabasso* (pp. 209–233). Mahwah, NJ: Erlbaum.

Bråten, I., & Olaussen, B. S. (2005). Profiling individual differences in student motivation: A longitudinal cluster-analytic study in different academic contexts. *Contemporary Educational Psychology*, 30, 359–396.

Bråten, I., & Samuelstuen, M. S. (2004). Does the influence of reading purpose on reports of strategic text processing depend on students' topic knowledge? *Journal of Educational Psychology*, 96, 324–336.

Bråten, I., & Strømsø, H. I. (2003). A longitudinal think-aloud study of spontaneous strategic processing during the reading of multiple expository texts. *Reading and Writing: An Interdisciplinary Journal*, 16, 195–218.

Bråten, I., & Strømsø, H. I. (2005). The relationship between epistemological beliefs, implicit theories of intelligence, and self-regulated learning among Norwegian post-secondary students. *British Journal of Educational Psychology*, 75, 539–565.

Bråten, I., & Strømsø, H. I. (2006a). Effects of personal epistemology on the understanding of multiple texts. *Reading Psychology*, 27, 457–484.

Bråten, I., & Strømsø, H. I. (2006b). Constructing meaning from multiple information sources as a function of personal epistemology: The role of text-processing strategies. *Information Design Journal*, 14, 56–67.

Bråten, I., & Strømsø, H. I. (2006c). Epistemological beliefs, interest, and gender as predictors of Internet-based learning activities. *Computers in Human Behavior*, 22, 1027–1042.

Bråten, I., & Weinstein, C. E. (2004). *Internet-specific Epistemological Questionnaire (ISEQ)*. Austin, TX: Department of Educational Psychology, University of Texas at Austin.

Bråten, I., Strømsø, H. I., & Olaussen, B. S. (2003). Self-regulated learning and the use of information and communications technology in Norwegian teacher education. In D. M. McInerney & S. Van Etten (Eds.), *Research on sociocultural influences on motivation and learning: Sociocultural influences on teacher education programs* (Vol. III, pp. 199–221). Greenwich, CT: Information Age Publishing.

Bråten, I., Strømsø, H. I., & Samuelstuen, M. S. (2005). The relationship between internet-specific epistemological beliefs and learning within internet technologies. *Journal of Educational Computing Research*, 33, 141–171.

Bråten, I., Strømsø, H. I., & Samuelstuen, M.S. (2007). *Topic-specific epistemological beliefs moderate the effect of task instruction on multiple text comprehension*. Paper presented at the biennial meeting of the European Association for Research on Learning and Instruction, Budapest, Hungary.

Cerdan, R., & Vidal-Abarca, E. (in press). The effects of tasks on integrating information from multiple documents. *Journal of Educational Psychology*.

Guthrie, J. T., Wigfield, A., Barbosa, P., Perencevich, K. C., Taboada, A., Davis, M. H., et al. (2004). Increasing reading comprehension and engagement through concept-oriented reading instruction. *Journal of Educational Psychology*, 96, 403–423.

Hartley, K., & Bendixen, L. D. (2001). Educational research in the Internet age: Examining the role of individual characteristics. *Educational Researcher*, 30(9), 22–26.

Hartley, K., & Bendixen, L. D. (2003). The use of comprehension aids in a hypermedia environment: Investigating the impact of metacognitive awareness and epistemological beliefs. *Journal of Educational Multimedia and Hypermedia*, 12, 275–289.

Hofer, B. K. (2004). Epistemological understanding as a metacognitive process: Thinking aloud during online searching. *Educational Psychologist*, 39, 43–55.

Hofer, B. K., & Pintrich, P. R. (1997). The development of epistemological theories: Beliefs about knowledge and knowing and their relation to learning. *Review of Educational Research*, 67, 88–140.

Jacobson, M. J., & Spiro, R. J. (1995). Hypertext learning environments, cognitive flexibility, and the transfer of complex knowledge: An empirical investigation. *Journal of Educational Computing Research*, 12, 301–333.

Kim, H. S., & Kamil, M. L. (2003). Electronic and multimedia documents. In A. P. Sweet & C. E. Snow (Eds.), *Rethinking reading comprehension* (pp. 166–175). New York: Guilford Press.

Kardash, C. M., & Howell, K. L. (2000). Effects of epistemological beliefs and topic-specific beliefs on undergraduates' cognitive and strategic processing of dual-positional text. *Journal of Educational Psychology*, 92, 524–535.

Kardash, C. M., & Scholes, R. J. (1996). Effects of preexisting beliefs, epistemological beliefs, and need for cognition on interpretation of controversial issues. *Journal of Educational Psychology*, 88, 260–271.

Kim, H. J. J., & Millis, K. (2006). The influence of sourcing and relatedness on event integration. *Discourse Processes*, 41, 51–65.

King, P. M., & Kitchener, K. S. (1994). *Developing reflective judgment: Understanding and promoting intellectual growth and critical thinking in adolescents and adults*. San Francisco, CA: Jossey-Bass.

Kintsch, W. (1988). The role of knowledge in discourse comprehension: A construction-integration model. *Psychological Review*, 95, 163–182.

Kurby, C. A., Britt, M. A., & Magliano, J. P. (2005). The role of top-down and bottom-up processes in between-text integration. *Reading Psychology*, 26, 335–362.

Leu, D. J. (2000). Literacy and technology: Deictic consequences for literacy education in an information age. In M. L. Kamil, P. B. Mosenthal, P. D. Pearson, & R. Barr (Eds.), *Handbook of reading research* (Vol. III, pp. 743–770). Mahwah, NJ: Erlbaum.

Linderholm, T., & van den Broek, P. (2002). The effects of reading purpose and working memory capacity on the processing of expository text. *Journal of Educational Psychology*, 94, 778–784.

Mason, L., & Boscolo, P. (2004). Role of epistemological understanding and interest in interpreting a controversy and in topic-specific belief change. *Contemporary Educational Psychology*, 29, 103–128.

Mason, L., Scirica, F., & Salvi, L. (2006). Effects of beliefs about meaning construction and task instructions on interpretation of narrative text. *Contemporary Educational Psychology*, 31, 411–437.

Meyer, A., & Rose, D. H. (1998). *Learning to read in a computer age*. Peabody, MA: Center for Applied Special Technology.

Narvaez, D., van den Broek, P., & Ruiz, A. B. (1999). The influence of reading purpose on inference generation and comprehension in reading. *Journal of Educational Psychology*, 91, 488–496.

National Reading Panel (2000). *Teaching children to read: An evidence-based assessment of the scientific research literature on reading and its implications for reading instruction*. Washington, DC: National Institute of Child Health and Human Development.

Paxton, R. J. (1999). A deafening silence: History textbooks and the students who read them. *Review of Educational Research*, 69, 315–339.

Perfetti, C. A., Britt, M. A., & Georgi, M. C. (1995). *Text-based learning and reasoning: Studies in history*. Hillsdale, NJ: Erlbaum.

Perry, W. G. (1970). *Forms of intellectual and ethical development in the college years: A scheme*. New York: Holt (Rinehart& Winston).

Rouet, J. F. (2006). *The skills of document use: From text comprehension to Web-based learning*. Mahwah, NJ: Erlbaum.

Rouet, J. F., Britt, M. A., Mason, R. A., & Perfetti, C. A. (1996). Using multiple sources of evidence to reason about history. *Journal of Educational Psychology*, 88, 478–493.

Royer, J. M., Carlo, M. S., Dufresne, R., & Mestre, J. (1996). The assessment of levels of domain expertise while reading. *Cognition and Instruction*, 14, 373–408.

Samuelstuen, M. S., & Bråten, I. (2005). Decoding, knowledge, and strategies in comprehension of expository text. *Scandinavian Journal of Psychology*, 46, 107–117.

Samuelstuen, M. S., & Bråten, I. (2007). Examining the validity of self-reports on scales measuring students' strategic processing. *British Journal of Educational Psychology*, 77, 351–378.

Schommer, M. (1990). Effects of beliefs about the nature of knowledge on comprehension. *Journal of Educational Psychology*, 82, 498–504.

Schommer, M. (1998). The influence of age and schooling on epistemological beliefs. *British Journal of Educational Psychology*, 68, 551–562.

Schommer, M., & Walker, K. (1995). Are epistemological beliefs similar across domains? *Journal of Educational Psychology*, 87, 424–432.

Schommer, M., Crouse, A., & Rhodes, N. (1992). Epistemological beliefs and mathematical text comprehension: Believing it is simple does not make it so. *Journal of Educational Psychology*, 84, 435–443.

Schommer-Aikins, M., & Easter, M. (2004, April). *Relationships among ways of knowing, epistemological beliefs, and academic performance*. Paper presented at the annual meeting of the American Educational Research Association, San Diego, CA.

Schraw, G. (2000). Reader beliefs and meaning construction in narrative text. *Journal of Educational Psychology*, 92, 96–106.

Schraw, G., & Bruning, R. (1996). Readers' implicit models of reading. *Reading Research Quarterly*, 31, 290–305.

Schraw, G., & Bruning, R. (1999). How implicit models of reading affect motivation to read and reading engagement. *Scientific Studies of Reading*, 3, 281–302. Schraw, G., & Sinatra, G. M. (2004). Epistemological development and its impact on cognition in academic domains. *Contemporary Educational Psychology*, 29, 95–102.

Schraw, G., Bendixen, L. D., & Dunkle, M. E. (2002). Development and validation of the Epistemic Belief Inventory (EBI). In B. K. Hofer & P. R. Pintrich (Eds.), *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 261–275). Mahwah, NJ: Erlbaum.

Spiro, R. J., Feltovich, P. J., Jacobson, M. J., & Coulson, R. L. (1991). Cognitive flexibility, constructivism, and hypertext: Random access instruction for advanced knowledge acquisition in ill-structured domains. *Educational Technology*, 31(5), 24–33.

Spiro, R. J., Coulson, R. L., Feltovich, P. J., & Anderson, D. K. (1994). Cognitive flexibility theory: Advanced knowledge acquisition in ill-structured domains. In R. B. Ruddell, M. R. Ruddell, & H. Singer (Eds.), *Theoretical models and processes of reading* (pp. 602–615). Newark, DE: International Reading Association.

Spiro, R. J., Feltovich, P. J., & Coulson, R. L. (1996). Two epistemic world-views: Prefigurative schemas and learning in complex domains. *Applied Cognitive Psychology*, 10, S51–S61.

Stahl, S. A., Hynd, C. R., Britton, B. K., McNish, M. M., & Bosquet, D. (1996). What happens when students read multiple source documents in history? *Reading Research Quarterly*, 31, 430–456.

Strømsø, H. I., & Bråten, I. (2002). Norwegian law students' use of multiple sources while reading expository texts. *Reading Research Quarterly*, 37, 208–227.

Strømsø, H. I., Bråten, I., & Samuelstuen, M. S. (2003). Students' strategic use of multiple sources during expository text reading. *Cognition and Instruction*, 21, 113–147.

Trabasso, T., & Bouchard, E. (2002). Teaching readers how to comprehend text strategically. In C. C. Block & M. Pressley (Eds.), *Comprehension instruction: Research-based best practices* (pp. 176–200). New York: Guilford Press.

Valanides, N., & Angeli, C. (2005). Effects of instruction on changes in epsistemological beliefs. *Contemporary Educational Psychology*, 30, 314–330.

van den Broek, P., Lorch, R. F., Linderholm, T., & Gustafson, M. (2001). The effects of readers' goals on inference generation and memory for texts. *Memory & Cognition*, 29, 1081–1087.

Wiley, J., & Voss, J. F. (1999). Constructing arguments from multiple sources: Tasks that promote understanding and not just memory for text. *Journal of Educational Psychology*, 91, 301–311.

Wineburg, S. (1991). Historical problem solving: A study of the cognitive processes used in the evaluation of documentary and pictorial evidence. *Journal of Educational Psychology*, 83, 73–87.

Wineburg, S. (1998). Reading Abraham Lincoln: An expert/expert study in the interpretation of historical texts. *Cognitive Science*, 22, 319–346.

Wolfe, M. B. W., & Goldman, S. R. (2005). Relations between adolescents' text processing and reasoning. *Cognition and Instruction*, 23, 467–502.

Chapter 18
Epistemic Metacognition in the Context of Information Searching on the Web

Lucia Mason and Angela Boldrin

18.1 Introduction

After Perry's (1969) pioneering work, research on the psychology of epistemic beliefs, that is, personal beliefs about knowledge and knowing (Hofer & Pintrich, 2002), has flourished since the beginning of the 1990s. At least three major lines of investigation can be identified in the literature, the first of which deals with the development of epistemic thinking. According to developmental psychologists, it can be conceived as a cognitive structure comprising coherent and integrated representations, which characterize a level or stage of cognitive development. This cognitive structure has been described in relation to the ways of knowing (Belenky et al., 1986), epistemological reflection (Baxter Magolda, 1992), reflective judgment (King & Kitchener, 1994), relativistic thinking (Chandler et al., 1990), and argumentative reasoning (Kuhn, 1991).

The second line of investigation on epistemic beliefs deals with the influence on learning processes. It has been documented that representations about knowledge and knowing affect reading comprehension (Schommer et al., 1992); metacomprehension (Ryan, 1984; Schommer, 1990); interpretation of controversial topics (Schommer, 1990; Kardash & Scholes, 1996; Mason & Boscolo, 2004); ill-defined problem-solving (Schraw et al., 1995); transfer of learning (Jacobson & Spiro, 1995); and conceptual change (Mason, 2002, 2003; Mason & Gava, 2007; Qian & Alvermann, 1995; Sinatra et al., 2003; Windschitl & Andre, 1998).

The third line of investigation into epistemic beliefs concerns beliefs about specific areas of knowledge and knowing. As pointed out by Hofer (2006) in response to Muis et al. (2006), individuals' beliefs about knowledge and knowing can be identified as general epistemic beliefs (e.g., Schommer, 1990), a disciplinary perspective on beliefs (e.g., Buehl et al., 2002) and as discipline-specific beliefs, such as mathematics (e.g., Muis, 2004) or science (e.g., Driver et al., 1996).

Despite divergences in the terminology, focus, and methodology of research on beliefs about knowledge and knowing, a common aspect can be identified in the

University of Padua, Padova, Italy

M. S. Khine (ed.), *Knowing, Knowledge and Beliefs: Epistemological Studies across Diverse Cultures.*

decontextualized way that these beliefs have been generally tapped. The underlying presupposition is that they are individual assumptions that a person knows and recognizes (Hofer, 2004). The wide use of self-report questionnaires as a means to measure epistemic beliefs, especially in educational psychology studies, indicates decontextualization as a main feature of most investigations.

The aim of this chapter is to contribute to extending existing research by dealing with epistemic thinking as a situated metacognitive activity, that is, with the activation of beliefs about knowledge and knowing in a particular context of inquiry. We are specifically interested in examining the effects of these beliefs in the practice of searching information on the World Wide Web. Today, even young students often surf the Net for information on an unfamiliar topic. To effectively access, identify, and use Internet-based material is not only a question of formulating efficient search queries or revising them in an appropriate way. It is also a question of evaluating the truthfulness of what has been found. Making judgments to validate conclusions and apply the knowledge learned during the search process implies the activation in context of assumptions about the nature of knowledge and knowing.

The chapter first situates epistemic beliefs within metacognitive processes to include them into a more general model of cognition. The relationship between epistemic beliefs and context is then discussed to posit that they should be examined in practice and not in a decontextualized manner. The context of information searching on the Web will then be considered as a new technological learning environment requiring that an individual be epistemically active in order to be a sophisticated user of information. Findings from three studies involving university, high, and middle school students will illustrate different aspects of the spontaneous and solicited activation of epistemic metacognition to monitor and judge online information, and the retrospective evaluation of knowledge sources. Implications for future research and reflections from the educational point of view conclude the chapter. We use throughout the adjective “epistemic” instead of “epistemological,” which is more popular in the literature. We concur with Alexander and Sinatra (2007) and Hofer (2004) that, for terminological clarification, epistemological beliefs should be conceived in terms of beliefs about epistemology, that is, beliefs about the study of knowledge. In contrast, epistemic beliefs refer to beliefs about knowledge. Accordingly, since we focus on personal beliefs about the nature, source, and justification of knowledge, we call them epistemic.

18.2 Epistemic Beliefs and Metacognitive Processes

A particularly relevant issue of the recent research on beliefs about knowledge and knowing is the conceptualizing of epistemic thinking as a metacognitive process. In the 1980s, Kitchener (1983) situated epistemic thinking within a model of cognition by distinguishing three levels of cognitive processing: Cognition, metacognition, and epistemic cognition. The first level includes cognitive processes such as perceiving, reading, and writing. The second level comprises all metacognitive processes through which knowledge about cognitive tasks is activated, for instance, the application of a strategy, as well as the monitoring of its use. The third level, the epistemic, that is, knowing about knowing, concerns an understanding and awareness of the nature of knowledge and justification criteria for the knowing process. According to Kitchener (1983), epistemic cognition is involved in reasoning about ill-structured problems for which there is no single right answer (e.g., the problem of why some students fail at school or why some criminals are recidivist). It seems that Kitchener (1983) distinguished epistemic from metacognitive cognition to refer to a more general and abstract level of knowing about knowing.

Recently, Kuhn (1999, 2000) used the higher-order term "meta-knowing" to include any cognition about cognition. There are three levels of meta-knowing that can be identified according to her model of cognitive development: The cognitive, strategic, and epistemological. Cognitive meta-knowing is knowing about declarative knowing (knowing that), while strategic meta-knowing is about procedural knowledge (knowing how). Epistemological, the more general and abstract type of meta-knowing, refers to a wider understanding of what knowledge and knowing are, in general ("How does one come to know?") and personally ("What do I know of what I know?"). Regardless of the various levels at which epistemic thinking is situated, that is, as part of or beyond metacognition, beliefs about knowledge and knowing fit into a wider scheme of cognitive development.

More recently, Hofer (2004), who took into account both Kitchener's and Kuhn's models, extended the theoretical issue of the conceptualization of epistemic thinking at the metacognitive level. She posited that it should be conceived as a metacognitive process that activates a set of beliefs organized around dimensions. She moved from the consideration that the various models of metacognition (Flavell, 1979), although varying in the components involved, are essentially three-component classic models of metacognition (e.g., Pintrich et al., 2000). This encompasses the components of metacognitive knowledge, metacognitive judgments and monitoring, self-regulation and control of cognition and learning. Hofer (2004) identified four dimensions of epistemic thinking and included them (Hofer, 2000) in the metacognitive realm. More specifically, if metacognitive knowledge includes individuals' knowledge about themselves as learners and thinkers, and about tasks and strategies, this concept can also be expanded to include knowledge about knowledge in itself. In this regard, the two dimensions of beliefs about the nature of knowledge, that is, certainty of knowledge (to what extent knowledge is considered static and stable rather than dynamic and evolving) and simplicity of knowledge (to what extent knowledge is considered as a set of discrete elements rather than a web of interconnected elements), fit the first component of the metacognitive model.

If metacognitive judgments and monitoring are process activated and lead learners to reflect about their comprehension and learning processes, as well as judgment of task difficulty, the conceptualization of these processes can be expanded to include epistemic monitoring and judgment. In this regard, the two dimensions of beliefs about the nature of knowing, that is, source of knowledge (to what extent knowledge is considered to be based outside the self and transmitted rather than constructed by reason) and justification for knowing (to what extent observation or omniscient authority, rather than shared rules of critical inquiry, are considered to accept claims) fit the second component of the metacognitive model. Epistemic processes at this level of metacognition include, for instance, evaluating information sources, weighing up evidence in support of knowledge claims, integrating contrasting information, reconciling one's own point of view with that of experts.

Finally, if self-regulation and control of cognition in the metacognitive model refer to all self-regulatory processes of learning, these processes can be expanded to include epistemic aspects of knowledge construction at this level. As pointed out by Hofer (2004), this component of metacognition implies intentionality in dealing with knowledge in the knowing process. For instance when one decides that he or she knows enough about a topic, or that further evidence should be collected to support a knowledge assertion, and not to prematurely close the inquiry on a controversial topic. Empirical evidence of the epistemic nature of metacognitive processes activated by students asked to discover more about a topic by relying on Internet-based informational resources, will be provided later in this chapter.

18.3 Epistemic Beliefs and Context: A Critical Issue

One of the criticisms that has been raised about most research on epistemic beliefs regards the decontextualized nature of the investigation. It is mainly scholars interested in science teaching and learning (e.g., diSessa et al., 2003) who have posited that beliefs about knowledge and knowing cannot be identified at either a general-domain or specific-domain level, but only in a given context. Their perspective is based on an alternative ontology of epistemic beliefs: They should not be conceived as stable cognitive structures that an individual does or does not have, which are assumed to be consistent across contexts. Epistemic beliefs are conceptualized as less stable but context-sensitive cognitive resources. They can be activated in a given context and not in another as different contexts trigger different resources. For instance, a student may have multiple epistemological resources available regarding the source of knowledge. He or she may activate the resource that knowledge is "transmitted stuff" instead of "fabricated stuff," or that it is "a free creation" on the basis of the contextual variables of the situation in which the learning takes place, as revealed by classroom observations and individual interviews (diSessa et al., 2003; Louca et al., 2004). Empirical support for the argument that students draw upon different epistemic beliefs in different situations has been provided within the field of science education (e.g., Leach et al., 2000; Leach & Lewis, 2002).

We agree, and disagree, with this perspective. On one hand, we acknowledge that epistemic beliefs cannot be considered in isolation from the contextual variables in which they are activated. Therefore, if we assess them only decontextualized, we may fail to capture those beliefs appropriately. In fact, one of the difficulties in replicating the factor structure underlying Schommer's Epistemological

Questionnaire may be explained by referring to the decontextualization of the questions mentioned in the items, which may lead to different interpretations and undermine instrument validity. We agree that our understanding of the nature and role of representations about knowledge and knowing must be extended by examining epistemic beliefs in practice, that is, when they are activated in context. This implies that the use of self-report questionnaires should at least be integrated with more naturalistic tools. On the other hand, we do not think that students show only epistemic inconsistencies across situations. The need for a more context-sensitive assessment of epistemic beliefs, which are situated and influenced by the learning environment and tasks, does not necessarily imply that we cannot conceive that students possess (to some extent) a more generalized theory of knowledge and more specific theories activated in domains and situations. In the next sections we will focus on a particular context within which to examine the activation of epistemic beliefs, that is, the context of online information searching on the World Wide Web.

18.4 An Increasingly Common Learning Context: Information Searching on the Web

These days, online searching on the Web has become a routine way to identify and access the information needed to build knowledge, not only in academic contexts, but also in everyday life when more information is required about an unfamiliar topic (Nückles & Bromme, 2002; Tsai, 2004). It has recently been posited that Internet reading requires new literacy skills (Coiro, 2003; Leu, 2002; Zhang & Duke, 2005). The notion of literacy has indeed been extended to include new skills that learners must have in order to understand Web-based texts, as well as the traditional skills. In this regard, a position statement of the International Reading Association (2001) pointed out that traditional definitions of reading, in relation to technology, are insufficient, as are the instructional practices based on the very long tradition of reading books and other printed media. Online nonlinear hypertexts, multiple-media texts, and interactive texts are all examples of Internet texts with new characteristics, which provide new opportunities, but also new demands to the readers. Different types of processes are required to understand them, and different instructional strategies must be adopted to help students make meaning of Web-based nonlinear texts that include multiple media (Coiro, 2003). Empirical research has provided evidence, for example, that Internet reading implies new and different reading strategies according to the purposes of Internet surfing. A study with college students showed that if the purpose is to locate specific information, learners use search engines, then choose the web sites to read, keeping in mind their goals, and then scan the whole pages and judge them for usefulness and accuracy. If necessary, they narrow down the query words or quit a web site that turns out to be unhelpful. If the purpose is to acquire new knowledge, after accessing a web site and reading short descriptions, learners evaluate the degree of difficulty of the content to be learned and decide whether to continue, seek diagrams and charts to understand better, reread when the content is not clear, distinguish between genres, or go to other web sites for a different opinion on the topic. Prior knowledge about how different search engines work is a powerful resource in the prereading phase across purposes. During reading, across purpose processes include monitoring the understanding of the content and evaluation of the web sites' credibility (Zhang & Duke, 2005).

Pertinent to the focus of this chapter is that new literacy skills include being able to evaluate the credibility of web sites, a task that is accomplished on the epistemic level.

A simple click of the mouse makes a huge amount of information available for analysis and comparison (Hess, 1999). Almost anybody can publish almost anything on the Web inexpensively, without undergoing any peer review or editorial processes. In the past, the difficult task of controlling the accuracy and relevance of information was traditionally carried out by editors and publishing companies. In the Internet era, this task is transferred to the students themselves, who must identify, compare, evaluate, and interpret the information they access on the Web (Bråten & Strømsø, 2006; Bråten et al., 2005). In the past, classrooms were entirely dependent on teachers and books, whose authority was well known. Today they rely more and more on the various information resources available on the Internet. To be able to validate online information, to distinguish between facts and opinions, supported and unsupported knowledge assertions, to recognize bias or commercial propaganda, requires adopting a critical stance.

Critical and flexible reading of the new media is not compatible with passively absorbing information, but rather implies framing arguments, considering evidence, and formulating judgments critically (Brunner & Tally, 1999). Unfortunately, what emerges from the real learning contexts is that students, even at college level, may lack those skills and turn out to be ineffective thinkers when they surf the Internet. As pointed out by Hofer (2004), the increase in web site citations in papers written by American students for academic requirements has led to outcry among academics (e.g., Rothenberg, 1997). There are complaints that university students are unable to perceive differences in types of information sources, or rigorously evaluate the credibility and veracity of what they read on the Web. Courses have been set up to instruct on how to access information and guidebooks have been published on the topic by professionals in information science (e.g., Alexander & Tate, 1999). In Web-based searching students may certainly experience information overload and need information processing skills to minimize it (Hess, 1999). It appears especially relevant to educational psychology to examine the extent to which students assess and judge the veracity of what they read when they begin to construct knowledge on an unfamiliar topic; what information sources they accept as authoritative and why, what kind of evidence they believe is an acceptable justification, how certain they are that what they read is true and believable, how they integrate their own experience with experts' knowledge, how they deal with contrasting knowledge assertions, and on the basis of what criteria do they decide that they have collected sufficient information on a topic, and have an adequate understanding of it. These aspects of investigation all reflect questions that regard the activation of beliefs about knowledge and knowing (Hofer, 2004), or epistemic theories if we assume that these beliefs are integrated and organized into a coherent whole.

18.5 The Need for Epistemic Judgment of Online Information

Students who surf the Internet to discover more about a topic must be able to engage themselves in metacognitive processes that have been well known to psychologists for a long time, such as monitoring the application of reading strategies, controlling and self-regulating their understanding (Brown, 1978; Flavell, 1979). They must also be engaged in other metacognitive processes, rarely investigated, which involve epistemic monitoring, judgment, and self-regulation (Hofer, 2004). To deal with a large amount of often contradictory information without being overwhelmed, they are asked to evaluate the source of knowledge, determine justification for knowing, and self-regulate their process of knowledge construction. In other words, they must ask themselves: "Is this piece of information credible?"; "Is it certain?"; "What is the evidence that supports it?"; "Are theory and evidence aligned?"; "Is this consistent with my own experience or knowledge?"; "How can this perspective be reconciled with what I know?"; "Do I know enough now or do I need more information?" Students' epistemic monitoring and judgments are based on their beliefs about knowledge and knowing. For instance, believing knowledge to be certain, absolute, simple and comprising many discrete facts, or believing knowledge to be a complex system of continuously evolving and interconnected elements can make a difference to the access, identification, and understanding of online information. Similarly, to believe that knowledge claims should not be justified in the light of evidence as they are a mere reproduction of reality, or that knowledge claims are idiosyncratic and incomparable, or that knowledge claims can be compared and rationally evaluated on the basis of shared norms of inquiry, may produce different effects on the interpretation and integration of information. Different epistemic beliefs may therefore have a different impact on online searching, reasoning modes, and decision-making.

Web sites provide rich opportunities for students to activate their epistemic judgments. They may lack evidence supporting their information, or present evidence that cannot be corroborated or is insufficient. Web sites therefore challenge students' argument evaluation skills. The few empirical studies that deal with student interaction with sites have indeed investigated students' evaluation of scientific arguments on the Web. Brem et al. (2001) examined the interaction between the electronic environment, the classroom, students (in grades 9, 11, and 12), and their critical thinking. The authors moved from the theoretical stance that argumentation skills and critical thinking should be analyzed in situation, as a relationship between context and reasoning, has emerged in recent research. Guidelines to help the students evaluate web sites were provided, introducing four criteria: Credibility, accuracy, reasonableness, and support of online information. According to the authors, *credibility* of a source refers to expertise and the absence of conflicts of interest or other motives. At least ideally, *accuracy* implies the corroboration of knowledge claims through independent sources. More realistically, accuracy criteria refer to information recency and accuracy, and the possibility that the details provided can be verified, once one has access to sufficient information. *Reasonableness* regards the extent to which online information is in line with students' viewpoints, and stems from experience and knowledge. In this regard, it should be pointed out that relying on common sense, if inconsistent and limited, can be problematic. *Support* concerns sound evidence that sustains a knowledge assertion.

After having been introduced to the four criteria, participants in the study visited six sites that included three typical Web environments: Hoaxes, weaker science sites, and stronger science sites. They were then asked to evaluate the sites, selecting one which they perceived to have low, moderate, or high degree of reliability. Findings revealed weaknesses in students' skills of argument. Stronger science sites were divided less into true and false, but underwent a lower level of systematic analysis. Students paid most attention to weaker and ambiguous science sites, which were divided into right or wrong in an absolutist way. In addition, despite the site type, they did not pay attention to the reporting of science, that is, the conduit of information, and considered only the argument presented on the site, while, especially on the Web, being able to recognize the conduit of science is crucial. Furthermore, little metacognitive reflection activity was revealed in assessing credibility or accuracy. Reasonableness was assessed mainly on the basis of common sense, even if the aim was to elicit the opposite response. Surface markers were much more widely used to assess support than underlying assumptions.

Part of a study with elementary school children also explored their assessment of the quality of information on the Internet (Schacter et al., 1998). They were asked to rate sites regarding their usefulness, truth, depth, practicability, helpfulness, and relevance. It emerged that students rated the truthfulness of all the information they came across on the Web as high, believing that all they obtained was true.

A more recent study was carried out by Clark and Slotta (2000) within the Knowledge Integration Environment (KIE). Designing science activities for this environment led researchers to explore the questions of how interpretation of evidence found on the Web is influenced by the perception of source authority and media enhancement of the sites. Fifteen-year-old students dealt with the scientifically controversial topic of dinosaur extinction. They were initially introduced to the two main theories about the phenomenon and were asked to rate their position about each theory along a continuum. They then read short biographies of two presenters – a university professor and a dinosaur enthusiast – without knowing the presenter of each theory. They then rated the credibility and knowledgeability of each presenter. They were asked to evaluate each piece of evidence available on the Internet and to explain in writing the importance of each to the ongoing scientific debate. Internet pages providing information about the causes of dinosaur extinction were manipulated to generate 12 pieces of evidence for the debate. Half the evidence supported the meteor impact theory and half the geological change theory. Relevant images were also collected to produce media-enhanced versions of each piece. Students received half the evidence items as media-enhanced. In addition, each piece of evidence was attributed to either the university professor or the dinosaur enthusiast, and participants again rated their preference between the theories as well as the knowledgeability of each presenter. Findings revealed that students who were given evidence of the meteor impact theory presented by the high authority, the professor, did not prefer this scientific account of the phenomenon compared with students who received the same evidence presented by the low authority, the dinosaur enthusiast. This indicates that students do not take into account the authority of the source when evaluating a theory. Overall, however, they did not choose a media-enhanced item over a text-only item as one of their most important pieces of evidence.

Interestingly, Norwegian undergraduate students' Internet-specific epistemic beliefs were measured using a self-report questionnaire and analyzed in relation to their learning with Internet technologies (Bråten et al., 2005). The items of the instrument were developed taking into account Hofer's (2000) epistemic dimensions. Theoretically, the two dimensions regarding Internet-based knowledge were labeled "Certainty of Internet-based knowledge" and "Simplicity of Internet-based knowledge." The two dimensions focused on Internet-based knowing were labeled "Source of knowledge" and "Justification for knowing." Outcomes from explorative and confirmatory factor analyses revealed a two-factor structure. The two factors were labeled "General Internet Epistemology" and "Justification for knowing." The first epistemic dimension reflected students' beliefs in Internet as an essential source of true, accurate, detailed, and factual knowledge. The second epistemic dimension reflected students' beliefs that Internet-based knowledge claims can be accepted with no critical evaluation. Regression analyses showed that students' personal beliefs about Internet predicted their self-reports regarding Internet-search and communication activities in more consistent and better ways than their motivational beliefs of self-efficacy while performing different Internet functions. This finding confirms that learner characteristics may have a crucial impact on learning activities in learning environments based on computer technologies (Hartley & Bendixen, 2001).

18.6 Epistemic Beliefs in Action: Findings From Studies on Internet-Based Information Searching and Evaluation

The above-mentioned studies focused on students' ability to evaluate arguments, taken from web sites, when explicitly asked to evaluate knowledge claims on the basis of suggested criteria. It appeared important to examine, first of all, if they are able to monitor and judge spontaneously the information encountered while surfing the Net to learn more about a given topic. To our knowledge, very few studies have investigated the spontaneous activation of epistemic metacognition in online information searching. One study involved a very small number of 5th graders who were asked to write a research paper on a chosen sportsperson by finding at least three sources of information. It was suggested that the students did not evaluate the information they gathered on the Web, as revealed by their thinking aloud during the online search (Hirsch, 1999). They trusted the information obtained and did not question the authoritativeness of its source.

Hofer's (2004) study investigated high school and college students' epistemic metacognition through an online search carried out as part of a simulated assignment for a science course. Details of the qualitative data analyses were not provided by the author, who summarized the findings in a theoretical paper. However, she indicated that thinking aloud seems to be a productive methodology to access students' thinking processes. Through it, she found evidence that students judged online information epistemically, although they did not necessarily have much awareness of an explicit epistemology during their search. They chose between books, journals, magazines, and web sites, but showed a limited understanding of the evolution of knowledge in a given field. Few of them really knew what peer review procedure actually means or how to independently determine criteria for knowledge validation.

In the next sections, data and issues from our wide research program on epistemic metacognition in practice will be discussed. Students of different educational levels, from elementary school to university were involved. Given the space constraints, we will summarize three studies: One with university students, one with high school students, and the third with middle school students.

18.6.1 Spontaneous Epistemic Monitoring and Judgment in University Students

The spontaneous activation of epistemic beliefs in the context of online information searching was explored in a study involving 41 undergraduates, 22 males and 19 females, from the Faculties of Psychology and Engineering of a large university in northern Italy (mean age: 22.4), balanced for expertise in online searching. Three main research questions guided the study: Do university students express comments indicating epistemic monitoring and judgment during online searching on the Internet? Is there evidence of the activation of beliefs about all the epistemic dimensions identified in the literature? Is their epistemic metacognition influenced by prior knowledge?

It was hypothesized that students would activate their epistemic beliefs, although at different levels of sophistication, especially regarding the source and justification of knowledge. It was also expected that students' prior knowledge would affect their epistemic metacognition during the search process, favoring those more familiar with the concept of electromagnetism and electromagnetic fields. Participants came to the laboratory individually and were assigned a simulated online searching assignment on the topic "Can the continuous use of mobile phones cause health hazards?" They were asked to imagine having to write a paper on the topic. Each participant was given 30 min search time. The methodology of thinking aloud was used to try to access students' epistemic thinking during searches on the Web. They were asked to express whatever came to their mind while surfing the Net to learn more about the question. Participants were video- and audio-recorded and the software "SPY 007" was used to monitor and "silently" record the key words they entered and all the web sites visited. Their prior knowledge was assessed through open-ended questions and their expertise in Internet searching by means of a short questionnaire. Only the data regarding thinking aloud is discussed here.

Recommendations for thinking aloud protocol analysis (Ericsson & Simon, 1993) and the treatment of verbal data (Chi, 1997) were taken into consideration in the qualitative analysis. In the process of identifying categories of comments and reflections expressed by the students spontaneously, we looked for evidence of the four epistemic dimensions specified in the literature. It emerged that students activated epistemic beliefs which referred to all the above-mentioned dimensions, although to different extents. A Cochran's test revealed that they referred significantly more to the justification and source of knowledge and less to the simplicity and certainty of knowledge, χ^2 (3) = 51.44, $p < .001$.

The coded data are summarized for each of the categories and subcategories identified, and an example is given to illustrate the content. The categories of verbal data are reported according to their level of sophistication, from the lowest to the highest.

1. *Source of knowledge*: 63% of students made judgments at the first level of epistemic evaluation focused on the information source. In particular, they judged the credibility of a web site by taking into account the following three aspects (percentages refer to the total judgments):

   (a) *Presence of an injured party* (3.8%), that is, someone claiming to have suffered damage caused by a mobile phone:

   Let me see the forums.… Yes, there is a forum to discuss mobile phones… no, no, this stuff is not credible. I must look for a person, a X person, who has suffered damages to find a credible source. (P36)

   (b) *Popularity of the source* (11.5%), that is, the degree to which it is well known:

   Here I'm on the site "Sustainable development and environment". It is the first that came out on cellular phones and health. It is about health and medicine. It is well known, I know it by name, it is pretty valid. (P39)

   (c) *Authoritativeness of the source* (92.3%), such as the sites of the World Health Organization (WHO) and the World Wildlife Fund (WWF) with a well-recognized expertise.

   I go back to Google and skip all sites like "newsmobile.it" as I have seen that there are very important sites, like WHO, which is authoritative. (P35)

2. *Justification for knowing*: 90% of the students made judgments at the second level of evaluation focused on the content of information supplied on the web sites they visited. In doing that, they activated their beliefs about the justification for knowing. Specifically, they referred to the following four criteria that varied in degree of sophistication (percentages refer to the total of judgments):

   (a) *Alignment with one's own point of view* (10.8%):

I have found another one, “elettra2000”. I have chosen to open it because a link says “the use of mobile phones causes cancer”. This is what I knew already, so I consider the information reliable. (P32)

(b) *Richness or recentness of the content* (64.9%):

There is also this site where the information is credible because there is a long bibliography on the topic. (P39)

…Health hazards are numerous and are indicated precisely… it is dated 2001, no, it is pretty old as a study. (P10)

(c) *Objective evidence* (8.1%):

This is about electrosmog. I’m visiting it as I’m looking for objective news rather than forums or people’s opinions. (P33)

… Here they argue that by logic it is to be said that the mobile phone is harmful… it is known that it emits radiation and that this is not harmless…the site has the name of a person, “lauraquinti.” I’ll put it among the non-reliable ones as the information offered is more of a personal position than objective fact. (P33)

(d) *Scientific evidence* (54.1%):

This stuff seems to be valid, there are recent scientific developments of medical policy and also a review of recent scientific evidence. (P9)

3. *Simplicity of knowledge* (44%): After evaluating the content of the information found and revealing their beliefs about the justification for knowing, a considerable number of students commented spontaneously on how “to treat” the obtained information. In doing so, they also activated their beliefs about the nature of knowledge. These beliefs regarded the extent to which knowledge is made up of discrete facts to be collected and added together, or contrasting claims to be compared and even combined and integrated. Reflections about the simplicity of knowledge revealed three levels of epistemic sophistication (percentages refer to the total of judgments):

(a) *Collection of information* (27.8%):

If I must prepare a paper, I will begin with the first site where they talk in general about the hazards derived from the use of the mobile phones, an issue which many journals and magazines worldwide have dealt with. Then, there is another, more specific site. Then, as the third part, I would use the site of the European Union with its regulations…. I would then take what I am interested in (P43).

(b) *Comparison of opposing claims* (44.4%):

I move from the assumption that the mobile phone is harmful, this is my starting point, therefore I look for both information that is in line with this point of view and information that is against it. (P34).

(c) *Comparison and integration of information sources* (27.8%):

It is a matter of information balance. If I look for something on the web site of TIM, which is the company that manages mobile phone communications, I’ll also look for the other point of view, for a site that gives me more reliable information about medical aspects, because there must be conflicting knowledge that does not coincide, as each side has its own views. At the end, I must generate a balanced knowledge. (P42)

4. *Certainty of knowledge*. Only four students (10%) spontaneously expressed reflections about the stability/instability of information they accessed on the Web. One of them activated the belief in the uncertain nature of some knowledge:

> I have just read a site that presents statistics about the number of people who buy mobile phones, the percentage increase in sales, etc., because I think that statistics are always the same, they cannot be refuted. (P6)

The other three participants appealed to the uncertain and changing character of the knowledge examined:

> The topic is controversial, it is not possible to find a single and clear position, which is 100% certain. It is never possible to say the definitive and ultimate thing… in the end we rely on studies, but we do not know what the right studies are. (P16)

Thinking aloud methodology made it possible to access students' epistemic thinking processes in the context of online searching. Overall, as expected, we found evidence that students formulated epistemic judgments when they metacognitively monitored their acquisition of knowledge while surfing the Web and beliefs regarding all four dimensions of epistemic theories were activated. In line with Hofer (2004), evidence of reflection about the source and justification of knowledge was more easily identified than evidence of reflection about the nature of knowledge, which was much less overtly verbalized. Epistemic beliefs seemed to operate interactively. If a source was evaluated as authoritative for the expertise recognized, the specific content of its information was also appreciated for objective or scientific evidence.

In addition, it should be pointed out that students' epistemic judgments were characterized by different levels of sophistication. Although not many, there were some learners who were guided by naive criteria for assessing the credibility of an information source, for instance reporting the one-sidedness or popularity of a controversial issue, as well as naive criteria of knowledge justification by appealing to the consistency of a knowledge claim with ones' own point of view. There were also students who expressed the belief in knowledge as a sum of facts that are not to be related but just added together.

Furthermore, especially noteworthy is that all students surfed the Web using only generic search engines, such as Google. Two of them, actually, accessed the web site of their university to visit the page "Health and Safety Services," where they did not find information on the topic. None of them, however, searched for more information using specialized databases such as the higher level search mechanisms to gain scientific data. This outcome leads us to reflect that although they know that different databases exist for various academic disciplines (i.e., PsychInfo for psychology), and must also use at least one of them to prepare their graduation dissertation (at the end of the academic year they are enrolled in), they do not transfer this "expertise" when asked to search more on a topic outside their academic field.

Nonparametric tests carried out to see whether students' prior knowledge on the topic influenced their spontaneous activation of epistemic metacognition revealed no significant differences in relation to any of the four epistemic dimensions. This unexpected outcome may be explained by referring to students' preexisting degree of knowledge, which was overall rather low and did not differentiate them to a significant extent. This outcome is related to the fact that no significant differences emerged between psychology and engineering students for epistemic metacognition.

18.6.2 Evaluation of Information Sources by High School Students

A second study involved 68 (45 girls and 23 boys) 11th and 12th graders (mean age: 17.2). It was aimed at examining: (1) What types of web site students visited when searching online information on a given topic, (2) what criteria they use to judge Internet information sources as credible or not, (3) the degree to which they consider Internet-based information as certain, (4) if the online information is perceived as consistent with their position on the question examined, (5) if they recognize information against their stance on the question, and (6) if the information used for the preparation of a report on the question is based on the credibility of the sources from which it is taken. Therefore, in this study we did not investigate the spontaneous activation of epistemic metacognition during the process of online searching through the methodology of thinking aloud, but rather we stimulated epistemic reflections at the end of that process. We collected data on post-search epistemic judgment by means of written open-ended questions, whose answers underwent a qualitative analysis.

In a school lab, participants were asked to search for Web information on the topic "Advantages and disadvantages of mandatory vaccinations" with the aim of writing a report. The topic is not scientifically controversial, although some disagreement has been voiced for certain vaccinations. It was chosen by the biology teacher who included it in her annual planning of curriculum units. Each lab computer was set up on the Google search engine home page for the search activity which could last up to 45 min. At the end of the search, students were asked to indicate: The three most and least credible information sources and justify the criteria behind their choice; whether they believed that the information obtained on the Web was certain; and whether they believed that this information was reasonable, that is, if it was consistent with their own views about the topic. Finally, they were asked to write a brief report on the topic by relying on the knowledge learned during the online search. Students' expertise in information research on the Web as well as their prior knowledge of vaccinations were controlled. SPY 007 software was also used in this study.

All web sites[1] visited by students were categorized into three groups: Institutional sites (e.g., the Italian ministry of health web site), partisan sites (e.g., a site of people advocating natural medicine), and online magazine sites (not of low level credibility). Some students evaluated as credible all sites they visited, including the partisan ones, although more judgments of credibility were made for institutional sources.

[1] Only Italian language web sites could be selected by students to avoid their foreign language skills interfering with the search process.

A chi-square analysis revealed that students significantly believed online magazines (38.2% of judgments) and partisan sites (37.2% of judgments) to be less credible than the institutional sites (23.4% of judgments). In contrast, they attributed more credibility to the latter than the former, X^2 (1) = 39.80, $p < .001$.

18.6.2.1 Source and Justification of Knowledge

A qualitative analysis of students' justifications for why they considered a source credible or not, led to the definition of eight criteria underlying their judgments. Of these eight, two (popularity and authoritativeness) are focused on a first level of evaluation, that is, the source itself. The other six criteria refer to the content of the source information, that is, a second level of epistemic evaluation (percentages refer to the total judgments):

(a) *Completeness* (41.2%)

> The web site presented all the essential aspects of knowledge about vaccinations. These aspects are exhaustive and examples and data are provided. (P1)

(b) *One-sidedness* (pro, 17.6%):

> The information about mandatory vaccinations that deals with the advantages, safety and reasons why they are necessary according to the experts was useful. (P67)

(c) *One-sidedness* (against, 10.3%):

> It is credible because it explains the disadvantages of vaccines very well and, above all, the toxic substances that are in them. (P46)

(d) *Both-sidedness* (26.5%):

> Although most vaccinations may cause some side effects, some are entirely without complications and are recommended. Other vaccinations are important to particular groups, they are thus recommended selectively. In addition, it is said that some pharmaceutical companies produce vaccines illegally, containing highly toxic substances considered to be carcinogenic. (P3)

(e) *Expository clarity* (26.5%):

> The ministry of health site must be very clear and in fact it is. I found it pretty clear and simple. (P11)

(f) *Popularity* (4.4%):

> It is a well-known site, with millions of visitors, which is why I think it is credible. (P22)

(g) *Authoritativeness* (39.7%):

> The Ministry of Health site is a State site, and I do not think the State gives false information. (P23)

(h) *Scientificity* (11.8%):

> It provides some essential statistics, for instance, the percentages of hospitalizations because of vaccinations. In 1995, there were about 13,000 cases of chickenpox requiring hospitalization, which amounts to 0.025% of annual hospitalizations. (P8)

A series of Cochran's tests revealed that the focus on both-sidedness was attributed to institutional sources significantly more than to the other two types of Web sources, X^2 (2) = 13.88, p < .05. These nonparametric tests also confirmed that students appealed more to the criteria of authoritativeness when verbalizing epistemic judgments about institutional sites than online magazines or partisan sites.

18.6.2.2 Certainty of Knowledge

Students' comments about the certainty of Web information regarding the nature of knowledge were assigned to three categories:

(a) *Certainty* (29.4%):

> I believe that this information is stable because doctors have carried out many studies on vaccinations and their benefits; therefore, even if they continue the research, the findings will be the same for ever. (P59)

(b) *Specific uncertainty* (19.1%):

> I believe that some knowledge is certain, for example, knowledge regarding the Constitution or experiments accepted within the medical community. Other knowledge, in contrast, may be too partial as it tries to devalue, in some way, ideas conflicting with their views. (P18)

(c) *General uncertainty* (51.5%):

> All this information is changeable as research advances and it is possible that new vaccines will be produced, which have different consequences for people's health. (P5)

18.6.2.3 Consistency of Information with Own Point of View

Students were asked about the consistency of the information gathered with their own views. Their answers differed significantly, as revealed by a chi square analysis, X^2 (2) = 25.07, p <.001. Most students, 58.6%, maintained that they obtained information about the disadvantages of vaccinations, which was in line with their topic-specific belief. A small group, 5.2%, obtained information on the advantages that was consistent with it, while 36.2% maintained that the information focused on both advantages and disadvantages was aligned with their own views.

18.6.2.4 Conflict of Information with Own Point of View

To the question of whether they found Web information conflicting with their opinions, 14.7% of students maintained that they could not make this type of judgment as they did not have a stable view. Fewer students (5.2%) admitted that they did not find information against their opinion because they did not look for it. Many more students (44.8%) maintained that they did not come across any information conflicting with their opinion on mandatory vaccinations, and even more (50%) said that they found information in agreement with their views. A qualitative analysis of the answers given by the latter identified two categories of reflection on conflicting knowledge, whose distribution varied significantly, X^2 (1) = 12.45, p < .001:

(a) *Conflict based on pros* (82.8%):

> The sites that did not present negative aspects were against my point of view. (P37)

(b) *Conflict based on cons* (17.2%):

> I disagree with people who prefer to get sick rather than vaccinated. Vaccinations are an important step toward the destruction of viruses, but this is only feasible if everybody has vaccinations. (P4)

It is interesting to note that among the students (44.8%) who maintained that they did not find information conflicting with their point of view, only 34.6% believed in both advantages and disadvantages of vaccinations, therefore they came across information describing both aspects. Of the others, 57% believed only in the advantages. Given that their search process was entirely free, we cannot say whether they found conflicting information but did not take it into account or if they really did not find it because of a biased search.

18.6.2.5 Influence of Prior Knowledge

Students' prior knowledge of vaccinations differentiate significantly only for type of epistemic judgments, which regarded the certainty/uncertainty of knowledge. Interestingly, participants with a higher level of initial knowledge of vaccinations evaluated the information on the Web as uncertain more than participants with lower topic familiarity, as revealed by a Fisher test (p < .05). The difference between the two groups for prior knowledge mainly regarded judgments about the specific nature of knowledge uncertainty about vaccinations, which was believed to be related to the source and type of information provided.

Data about the searching process, which was influenced significantly by expertise in online information searching, are not discussed here.

18.6.2.6 Report on the Topic

Students were required to write a report summarizing the information they acquired about the topic by surfing the Net. Their texts were first analyzed for the number of information units. The information sources were then considered to see if they had been evaluated by the writers as credible or not. A t-test revealed that most text units were drawn from sources that the students trusted more than from sources judged as not reliable, t (67) = 29.22, p < .001.

Overall, it can be said that this group of high school students were able to discriminate between Internet-based information sources and attributed much more credibility to the most authoritative ones. In dealing with different, if not contrasting, information, most of them activated a belief in the uncertain nature of knowledge, although a considerable number reported a general conviction about the certainty of knowledge. The students' degree of prior knowledge influenced their epistemic judgments about specific aspects of knowledge uncertainty with regard to the question examined. Someone who knows more about a topic and is more familiar with its complexity, is more likely to believe that knowledge is uncertain especially in relation to the source and specific aspects of information.

In addition, half the students admitted retrieving and analyzing sources providing information conflicting with their own views, mostly based on emphasizing only the positive aspects of vaccinations. To some extent, this finding seems to indicate that students are more likely to adopt an evaluativist epistemic perspective (Kuhn & Weinstock, 2002), based on the belief that multiple knowledge claims are legitimate but, at the same time, they can critically compare and evaluate to see which are supported more than others. Another positive outcome is that students took into consideration information obtained from sources they had evaluated as more credible when writing a report at the end of their search. However, this outcome does not imply that they are able to produce high-level arguments that integrate multiple perspectives on a topic. Analyses in progress will reveal the quality of the argumentation in the reports.

18.6.3 Perception, Evaluation, and Combination of Contrasting Information Sources by Middle School Students

We extended further our research through a third study with 45 students in the 7th grade (24 boys and 21 girls; mean age: 12.8). As in the previous study with high school students, we stimulated participants' epistemic reflection at the end of a predefined search process, in this case through a retrospective interview. Given that the students were younger than those participating in previous studies, the main aim was to investigate whether the learners perceived conflicting online information about the topic. We were also interested in examining what they took into consideration when asked to evaluate a source as credible or not, and if they would really take into account all sources when preparing a text on the topic "Environmental pollution by metals: Copper." It was chosen by teachers as it had not already been dealt with but was included in one of the curriculum units to be implemented during the academic year. In a school lab, each student was introduced to the Google home page. The experimenter (second author) suggested the key words to enter so that three selected web sites could appear in random order. On each of these web sites they read an article. The web sites were:

(a) A magazine site (www.girodivite.it) that presents articles on current topics. Its declared aim is to improve the quality of journalistic information by paying attention to those news items that are overlooked and do not receive enough attention by newspapers, magazines, or TV. The article on this site was written by the WWF on the basis of a United Nations Environmental Program (UNEP) report about water pollution caused by metals.

(b) The site of "L'Istituto Italiano del Rame" (www.iir.it), that is, the site of the Italian Copper Association. It claims to be aimed at promoting the industrial use of copper and its alloys by spreading scientific and technical information. The article on this site dealt with the benefits of copper to the health of individuals as well as its contributions to public health because of its bacteriostatic properties.

(c) The Wikipedia web site (www.wikipedia.it), a multilingual online encyclopaedia, written collaboratively by volunteers with the aim of creating a free and accurate tool, characterized by the width and depth of the topics presented. The article on this site dealt with scientific aspects of copper: The natural characteristics, applications, and precautions to be taken against its compounds.

After reading the three articles, which were printed, the learners where individually interviewed and asked the following questions:

– Do the three sites you visited talk about the topic in the same way?
– Which source of information is the most credible in your opinion? For what reasons?
– Which source of information is the least credible in your opinion? For what reasons?
– Do you think that what is written on the three sites will change over time?
– If you were asked to write a text on the topic, what sources would you take information from?

At the end of each interview, the interviewee was asked to write a text on all that he or she learned on the topic by reading the web sites.

As expected, all participants had a very low prior knowledge of copper. Given the grade level, we also took reading comprehension skills into consideration. They were administered the Italian standardized test for the 7th grade (Cornoldi & Colpo, 1995) to identify students with reading difficulties. Only two were identified. They carried out all tasks with their classmates, but their performances were not considered in the analyses. Outcomes of an analysis of the transcriptions of audiotaped interviews are reported below.

18.6.3.1 Recognition of Multiplicity of Information

No diversity between sites was recognized by 15.6% of participants, such as in the following answer:

> The sites are all the same because they talk about copper, how to use it, how it is indispensable to health, and say that a little of it can be used. (P4)

About half the students (48.8%) recognized that the three web sites provided different information as verbalized by this participant:

> The sites talked about different topics regarding copper. For example, one says what it does for our health, the other says that Italy is one of the countries that pollutes the Mediterranean sea through the waste that flows into the sea, and the third talks about copper in pretty general way, by describing how it is used. (P16)

A total of 35.6% of students showed awareness that not only did their information differ but it was also in contrast, by reference to the partisan nature of a source, as appears in the following answer:

> The WWF site talks about pollution. It is the site of a famous association and is more specialized, but it is logical that if it is interested in nature, it is a bit more partisan. The site of the encyclopaedia presents the composition of copper in a more technical way. The site of the Italian Copper Institute talks about the health of the human body, how our body reacts to copper. (P20)

A chi-square analysis confirmed a statistically significant difference in the distribution of students' answers to the question, X^2 (2) = 7.6, p < .05.

18.6.3.2 Credibility of Knowledge Sources

Significant differences emerged for the answers to the question about source credibility, X^2 (2) = 7.6, p < .05. Half the participants (51%) judged Wikipedia as the most credible source, 31% the WWF article site, and 18% the Italian Copper Institute site.

18.6.3.3 Justification for Source Credibility

Three categories of justification were identified when analyzing qualitatively the reasons justifying the evaluation of source credibility. The distribution of answers into these categories was significantly different, χ^2 (2) = 8.53, p < .05:

(a) *Quantity of information* (51.1%):

> The encyclopaedia site is the most reliable because it talks about many things, more issues, and they are treated in-depth. (P19)

(b) *Consistency of information with own knowledge* (33.3%):

> The encyclopaedia site is certainly credible as it explains the same things that I studied in books about technical education. (P44)

(c) *Authoritativeness of the source* (15.6%):

> The WWF site is more credible because the article we read is a UNO treatise and, therefore, is not only a national thing, but also official. (P57)

Conversely, students' judgments about the lack of credibility of sites showed that most (47%) did not believe strongly in the information provided by the Italian Copper Institute. The site presenting the WWF article was judged not to be credible by 36% of participants, while Wikipedia was considered as such by 18%. The justifications for these judgments of non-credibility referred to three types of epistemic criteria:

(a) *Implausibility of evidence* (48.9%):

> The WWF site amazed me because it presented data about so much waste from Italy and in the Mediterranean sea. Frankly, it seemed to me to be far too much. (P21)

(b) *Unimportance or irrelevance of information* (42.2%):

> The least credible? Given that all three have been taken from Internet, maybe they are all credible, but the least is the site about health and copper because it is true that copper is useful for our health but it is not important to know that. I mean these are things, this is not important stuff. (P30).

(c) *Partisanship of information* (8.9%):

> In my opinion, the least credible is the site of the Italian association because it tries to trick us by describing only the positive things, by saying that copper is good to sell. (P42)
> Perhaps also the site with the WWF article, as it talked about negative things and it was obvious that they do not talk about the positive ones, but there are positive things. (P47)

The distribution of answers into these categories was significantly different, X^2 (2) = 12.4, p < .01.

18.6.3.4 Knowledge Change

Answers to the questions asked to activate students' beliefs about the stability of knowledge were assigned to four categories. Their distribution varied significantly, X^2 (4) = 27.8, p <.001:

(a) *No change* (8.9%): Knowledge is certain and does not develop.

> The three sites cannot change their content as copper is always the same, they cannot change it. (P50)

(b) *Multiple views-based change* (6.7%): Knowledge is not absolute and changes as each source has its own perspective and there will never be only one position on the topic:

> There can be some changes because each of them has an opinion on the topic. They do not agree on how copper should be used, therefore things may change and we never know the right point of view. (P25)

(c) *Partial change* (55.6%): Only some information is unstable and subject to change:

> The WWF site can change for sure because it is possible to do something to improve the environment, and the sea. The second site, the site of the Italian Institute for copper can also change, but the first site I saw, I think that it is quite difficult for it to change as it talks about the characteristics and uses of copper. (P33)

(d) *Research-based change* (28.8%): Knowledge is unstable and depends on the progress of research:

> They cannot always be the same, they change. For example, the site with WWF information will change if there is less pollution. On Wikipedia, the information about the quantity of copper that our bodies can bear, or our need for this metal, can change. To obtain this

> new information more accurate studies should be done and scientific research should continue until even a very small change can be perceived. (P47)

Most participants revealed a belief that some knowledge on the topic could change while some cannot, depending on the aspect being considered. Only a small number believed either in absolute knowledge about copper or in ever-changing multiple knowledge claims on the topic. Only a minimal percentage of learners mentioned that scientific research is the engine of knowledge change, through which new information is made available which can change previous information.

18.6.3.5 Prospective Information Combinations

To the question about which sources participants would take information from to write a text, most (66.7%) said they would rely on all three web sites ("because they say different things about the same topic"). Less participants (24.4%) maintained that they would use information from two sites (55% from Wikipedia and WWF; 36% from Wikipedia and the Italian Institute for copper; 8.9% from the latter and WWF). A chi-square analysis revealed a significant difference in the distribution of these answers, X^2 (2) = 24.13, $p < .001$.

18.6.3.6 Actual Combination of Information

At the end of the predefined search, students were asked to write a text about what they had learned from the web sites. As in the previous study, their texts were first analyzed in terms of the number of information units. The sources they had used were then examined to see if they were evaluated as credible or not. The outcomes of a t-test showed that there was a significant difference between the proportion of information units drawn from more credible sources and those from less credible ones, t (44) = 2.6, $p < .05$. Learners relied more on Internet-based sources that they trusted. If 67% of students maintained that they would consider all three sites if asked to write a text on what they learned, they actually referred to all the sources in writing their texts. A detailed analysis of the quality of the arguments generated is still in progress.

Overall, it can be concluded that almost half the 7th graders perceived that Web sources deal with the topic differently, but only 35% showed awareness that the knowledge provided on the sites was conflicting because of the one-sided perspective. In addition, there were some students, although not many (15.6%), who were unable to perceive the plurality of information they had read. In addition, only 15% of them made a judgment about the credibility of a web site by focusing on a first level epistemic evaluation, that is, on the degree of its recognized authoritativeness on the question. In contrast, more than double the number (33%) relied only on their knowledge to judge the credibility of a web site, and half of them took into consideration the quantity of information obtained. A number of students (29%)

believed that current knowledge on the topic could change in the future as scientific research provides new data. Most students said that they would use information from all the sites to prepare a text – which they then did – and this could have either a positive or negative result. It is positive in that it implies a recognition of multiple knowledge claims on the same issue which must be taken into account, combined, and integrated. It is negative if it implies that information is simply patched together.

18.7 General Discussion

The findings from the studies reported above indicate the plurality of aspects related to epistemic metacognition in the context of learning from the Web. The think-aloud study with university students provides evidence of their epistemic beliefs in practice, particularly about the source and justification of knowledge. They spontaneously monitored and judged online knowledge during their searching process, although at different levels of sophistication. There were some students, although not many, who used naive criteria to assess the credibility of an information source. In addition, it should be pointed out that the participants only used the general search engine Google. They did not access specialized databases although they knew them to be sources for finding scientific knowledge when preparing their degree dissertations. This confirms a finding from Hofer's (2004) study, which pointed out that college students' "encapsulated understanding." That is, they are less likely to apply their expertise in epistemic evaluation present in one domain, to a less familiar one. Interestingly, no differences emerged between psychology and engineering students in this regard.

The study with high school students revealed that most were able to discriminate between sources on the basis of their credibility, and to activate an epistemic belief in the uncertainty of knowledge to deal with different, even if not contrasting, knowledge claims. This belief in practice was significantly associated with their degree of prior knowledge on the topic. If they were more familiar with the topic, they believed more that the type of information source, as well as some specific aspects, contribute to knowledge uncertainty. Half the students also revealed awareness of conflicting information on the web sites they visited. They were also able to rely more on credible sources when writing a report on the topic examined, although this is not an indication of the generation of good arguments on multiple knowledge claims.

The study with middle school students indicates that most were unaware that the conflicting information between the sites was also due to partisan aspects of the information provided. Even more worrying is that there were students, albeit few, who did not recognize the plurality of views on the topic. Their epistemic beliefs about the justification of knowledge activated in the context were rather naive. This outcome is substantially in line with Brem et al.'s study (2001) showing students' weaknesses in argument evaluation, deriving from their epistemic beliefs.

The findings, overall, highlight both positive and negative issues regarding students' learning in the context of information searching on the Web. To some extent, and at each grade level considered, there is evidence of spontaneous or solicited evaluation of the credibility of electronic resources. However, at the same time, students show some fragility in epistemically judging the truthfulness of what they find on the Net. They often do not make epistemic evaluations at the first level, that is, they do not consider the authoritativeness of a source in itself or appeal to naive criteria of knowledge justification. The youngest in particular, if able to perceive conflicting information, are less aware, or totally unaware, of the underlying reasons, which are to be considered in evaluating the truthfulness of content. Prior knowledge seems to influence at least some aspects of epistemic judgment, favoring the activation of more sophisticated beliefs.

Future research is needed to examine other learner characteristics that may influence the activation of their beliefs about knowledge and knowing in the context of Web searching. As pointed out by Hartley and Bendixen (2001), the nature of new technologically supported learning environments may require, even more than the traditional environments, some learner characteristics. In this regard, self-regulatory skills, for instance, must be used to manage the large amount of information easily obtained on the Web. In addition, the role of thinking dispositions (Stanovich, 1999) – such as the need for cognition or open-minded thinking, as well as of epistemic motivation (Kruglanski, 1989) – seems to be worth investigating. They may interact with students' beliefs about knowledge and knowing in the monitoring and judgment of Internet-based electronic resources.

18.8 Concluding Remarks

Multimedia learning (Mayer, 2005) has become the focus of recent research in educational psychology. Theories or models of cognition have been developed or applied to learning processes based on technology that allows nonlinear and rapid access to multiple forms of information (e.g., Sweller, 2005). Today, the World Wide Web is a ubiquitous and powerful tool through which students can interact with the world for a plurality of purposes, as recently explored by developmental psychologists (Greefield & Yan, 2006). One such purpose is to access information in a vast, but uncontrolled way. It should therefore be considered that Internet presents both advantages and challenges to students. On the one hand, the Net provides very rich resources for good learning (e.g., Feldman et al., 2000 for science learning), while on the other, the issue of quality, truthfulness, and accuracy of the information found becomes crucial. Students must familiarize themselves with search queries and acquire skills to formulate and revise their queries when searching in subject areas that are not well known to them (Hirsch, 1999). They must also check the merit of the information they obtain, that is, monitor and judge it from the epistemic point of view, activating their beliefs about the nature of knowledge and knowing. At the same time, however, reflecting on the authoritativeness of knowledge sources, multiple perspectives of a topic, and the quality of arguments refines students' epistemic thinking by stimulating them to be engaged on a plane that has been defined as the highest level of meta-knowing (Kuhn, 1999), or the highest level of cognitive processing (Kitchener, 1983). The Internet therefore has a dual value as an epistemological tool (Tsai, 2004). It involves epistemic thinking to deal with the source, structure, and credibility of information provided, as well as stimulating and sustaining the refinement of thinking about knowledge and knowing. In this regard, for example, the core of the SCOPE (Science Controversies Online: Partnerships and Education) project, within a learning environment focused on knowledge integration (Linn et al., 1998), is facilitating students in learning about science concepts and understanding the nature of scientific inquiry by dealing with current scientific controversies debated on the Web (Bell & Linn, 2000). Evidence from longitudinal studies has shown that students refined their science epistemic beliefs through debate and argumentation (Bell & Linn, 2002).

To bring controversial topics into the classroom through the Internet – which is unparalleled in this regard – means emphasizing the importance of debate, argumentation, and critique in the process of scientific knowledge construction. This is crucial to help equip students with the more important tools for becoming lifelong learners. Since they are used to relying on textbooks, they need to be prepared, more than ever before, to evaluate Internet material with a critical eye in order to become sophisticated consumers of information. Schools today cannot ignore that critical thinking or reflective judgment skills in evaluating arguments on the electronic resources of the digital era may make a difference between students, a difference which in the past may not have emerged so clearly.

Acknowledgments This material is based on research program partially supported by the Jacobs Foundation, Zurich (Switzerland), under a dissertation grant to the second author. We are grateful for the contribution of the following students in the data collection: Nicola Ariasi, Gloria Gelain, and Angela Nardelli.

References

Alexander, J. E., & Tate, M. A. (1999). *Web wisdom: How to evaluate and create information quality on the Web*. Mahwah, NJ: Lawrence Erlbaum.

Alexander, P. A., & Sinatra, G. M. (2007). First steps: Scholars' promising movements into a nascent field of inquiry. In S. Vosniadou, A. Baltas, & X. Vamvakoussi (Eds.), *Reframing the conceptual change approach in learning and instruction*. Oxford: Elsevier.

Baxter Magolda, M. B. (1992). *Knowing and reasoning in college*. San Francisco, CA: Jossey-Bass.

Belenky, M. F., Clinchy, B. M., Goldberger, N. R., & Tarule, J. M. (1986). *Women' ways of knowing: The development of self, voice and mind*. New York: Basic Books.

Bell, P., & Linn, M. (2000). Scientific arguments as learning artifacts: Designing fo learning on the Web in KIE. *International Journal of Science Education*, 22, 797–817.

Bell, P., & Linn, M. (2002). Beliefs about science: How does science instruction contribute? In B. K. Hofer & P. R. Pintrich (Eds.), *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 321–346). Mahwah, NJ: Lawrence Erlbaum.

Bråten, I., & Strømsø, H. I. (2006). Epistemological beliefs, interest, and gender as predictors of Internet-based learning activities. *Computers in Human Behavior*, 22, 1027–1042.

Bråten, I., Strømsø, H. I., & Samuelstuen, M. S. (2005). The relationship between internet-specific epistemological beliefs and learning within internet technologies. *Journal of Educational Computing Research*, 33, 141–171.

Brem, S. K., Russell, J., & Weems, L. (2001). Science on the Web: Student evaluations of scientific arguments. *Discourse Processes*, 32, 191–213.

Brown, A. L. (1978). *Knowing when, where, and how to remember: A problem of metacognition*. In R. Glaser (Ed.), *Advances in instructional psychology* (Vol. 1, pp. 77–165). Hillsdale, NJ: Lawrence Erlbaum.

Brunner, C. B., & Tally, W. (1999). *The new media literacy handbook: An educator's guide to bringing new media into the classroom*. New York: Anchor Books.

Buehl, M. M., Alexander, P. A., & Murphy, P. K. (2002). Beliefs about schooled knowledge: Domain specific or domain general? *Contemporary Educational Psychology*, 27, 415–449.

Chandler, M., Boyes, M., & Ball, L. (1990). Relativism and stations of epistemic doubt. *Journal of Experimental Child Psychology*, 50, 370–395.

Chi, M. T. (1997). Quantifying qualitative analysis of verbal data: A practical guide. *Journal of the Learning Sciences*, 6, 271–315.

Clark, D. B., & Slotta, J. D. (2000). Evaluating media-enhancement and source authority on the Internet: The knowledge integration evaluation. *International Journal of Science Education*, 22, 859–871.

Coiro, J. (2003). *Reading comprehension on the Internet: Expanding our understanding ofreading comprehension to encompass new literacies*. Reading Online (www.readingonline.org/electronic/rt/2-03).

diSessa, A. A., Elby, A., & Hammer, D. (2003). J's epistemological stance and strategies. In G. M. Sinatra & P. R. Pintrich (Eds.), *Intentional conceptual change* (pp. 237–290). Mahwah, NJ: Lawrence Erlbaum.

Driver, R., Leach, J., Millar, R., & Scott, P. (1996). *Young people's images of science*. Buchingham: Open University.

Ericsson, K. A., & Simon, H. A. (1993). *Protocol analysis: Verbal report as data*. Cambridge, MA: MIT.

Feldman, A., Konond, C., & Coulter, B. (2000). *Network science a decade later: The Internet and classroom learning*. Mahwah, NJ: Lawrence Erlbaum.

Flavell, J. H. (1979). Metacognition and cognitive monitoring. *American Psychologist*, 34, 906–911.

Greenfield, P., & Yan, Z. (2006). Children, adolescents, and the Internet: A new field of inquirt in developmental psychology. *Developmental Psychology*, 42, 391–394.

Hartley, K., & Bendixen, L. D. (2001). Educational research in the Internet age: Examining the role of individual characteristics. *Educational Researcher*, 30, 22–26.

Hess, B. (1999). Graduate student cognition during information retrieval using the World Wide Web: A pilot study. *Computers & Education*, 33, 1–13.

Hirsch, S. (1999). Children's relevance criteria and information seeking on electronic resources. *Journal of the American Society for Information Science*, 50, 1265–1283.

Hofer, B. (2000). Dimensionality and disciplinary differences in personal epistemology. *Contemporary Educational Psychology*, 25, 378–405.

Hofer, B. (2004). Epistemological understanding as a metacognitive process: Thinking aloud during online searching. *Educational Psychologist*, 39, 43–55.

Hofer, B. (2006). Beliefs about knowledge and knowing: Integrating domain specificity and domain generality: A response to Muis, Bendixen, and Haerle. *Educational Psychology Review*, 18, 67–76.

Hofer, B. K. (2000). Dimensionality and disciplinary differences in personal epistemology. *Contemporary Educational Psychology*, 25, 378–405. Hofer, B. K., & Pintrich, P. R. (1997). The development of epistemological theories: Beliefs about knowledge and knowing and their relation to learning. *Review of Educational Research*, 67, 88–140.

Hofer, B. K., & Pintrich, P. R. (Eds.) (2002). *Personal epistemology*: *The psychology of beliefs about knowledge and knowing*. Mahwah, NJ: Lawrence Erlbaum.

International Reading Association (2001). *Integrating literacy and technology in the curriculum: A position statement*. Online document: http://www.reading.org/downloads/positions/ps1048_technology.pdf.

Jacobson, M. J., & Spiro, R. J. (1995). Hypertext learning environments, cognitive flexibility, and the transfer of complex knowledge: An empirical investigation. *Journal of Educational Computing Research*, 12, 301–333.
Kardash, C. M., & Scholes, R. J. (1996). Effects of preexisting beliefs, epistemological beliefs, and need for cognition on interpretation of controversial issues. *Journal of Educational Psychology*, 88, 260–271.
King, P. A., & Kitchener, K. S. (1994). *Developing reflective judgement*. San Francisco, CA: Jossey-Bass.
Kitchener, K. S. (1983). Cognition, metacognition, and epistemic cognition. *Human Development*, 26, 222–232.
Kruglanski, A. W. (1989). *Lay epistemics and human knowledge: Cognitive and motivational bases*. New York: Plenum.
Kuhn, D. (1991). *The skills of argument*. Cambridge: Cambridge University Press.
Kuhn, D. (1999). A developmental model of critical thinking. *Educational Researcher*, 28, 16–26.
Kuhn, D. (2000). Theory of mind, metacognition, and reasoning: A life-span perspective. In P. Mitchell & K. J. Riggs (Eds.), *Children's reasoning and the mind* (pp. 301–326). Hove, UK: Psychology Press.
Kuhn, D., & Weinstock, M. (2002). What is epistemological thinking and why does it matter? In B. K. Hofer & P. R. Pintrich (Eds.), *Personal epistemology. The psychology of beliefs about knowledge and knowing* (pp. 121–144). Mahwah, NJ: Lawrence Erlbaum.
Kuhn, D., Cheney, R., & Weinstock, M. (2000). The development of epistemological understanding. *Cognitive Development*, 15, 309–328.
Leach, J., & Lewis, J. (2002). The role of students' epistemological knowledge in the process of conceptual change in science. In M. Limón & L. Mason (Eds.), *Reconsidering conceptual change* (pp. 201–216). Dordrecht, The Netherlands: Kluwer.
Leach, J., Millar, R., Ryder, J., & M.-G. Séré (2000). Epistemological understanding in science learning: The consistency of representations across contexts. *Learning and Instruction*, 10, 497–527.
Leu, D. J. Jr. (2002). Literacy and technology: Deictic consequences for literacy education in an information age. In M. L. Kamil, P. B. Mosenthal, P. D. Pearson, & R. Barr (Eds.), *Handbook of reading research* (Vol. 3, pp. 743–770). Mahwah, NJ: Lawrence Erlbaum.
Linn, M., Bell, P., & Hsi, S. (1998). Using the Internet to enhance student understanding of science: The Knowledge Integration Environment. *Interactive Learning Environments*, 6, 4–38.
Louca, L., Elby, A., Hammer, D., & Kagey, T. (2004). Epistemological resources: Applying a new epistemological framework to science instruction. *Educational Psychologist*, 39, 57–68.
Mason, L. (2002). Developing epistemological thinking to foster conceptual changes in different domains. In M. Limón & L. Mason (Eds.), *Reconsidering conceptual change. Issues in theory and practice* (pp. 301–335). Dordrecht, The Netherlands: Kluwer.
Mason, L. (2003). Personal epistemologies and intentional conceptual change. In G. M. Sinatra & P. R. Pintrich (Eds.), Intentional conceptual change (pp. 199–236). Mahwah, NJ: Lawrence Erlbaum.
Mason, L., & Boscolo, P. (2004). Role of epistemological understanding and interest in interpreting a controversy and in topic-specific belief change, *Contemporary Educational Psychology*, 29,103–128.
Mason, L., & Gava, M. (2007). Effects of epistemological beliefs and learning text structure on conceptual change. In S. Vosniadou, A. Baltas, & X. Vamvakoussi (Eds.), *Reframing the Conceptual Change Approach in Learning and Instruction* (pp. 165–197). Oxford: Elsevier.
Mayer, R. E. (Ed.) (2005). *The Cambridge handbook of multimedia learning*. New York: Cambridge University Press.
Muis, K. R. (2004). Personal epistemology and mathematics: A critical review and synthesis of research. *Review of Educational Research*, 9, 47–58.
Muis, K. R., Bendixen, L. D., & Haerle, F. C. (2006). Domain-generality and domain-specificity in personal epistemology research: Philosophical and empirical reflections in the development of a theoretical framework. *Educational Psychology Review*, 18, 3–54.
Nuckles, & Bromme, R. (2002). Internet experts' planning of explanations for laypersons: A web experimental approach in the Internet domain. *Experimental Psychology*, 49, 292–304.

Perry, W. G. Jr. (1969). *Forms of intellectual and ethical development in the college years: A scheme*. New York: Holt (Rinehart and Winston).

Pintrich, P. R., Wolters, C. A., & Baxter, G. P. (2000). Assessing metacognition and self-regulated learning. In G. Schraw & J. C. Impara (Eds.), *Issues in the measurement of metacognition*. Lincoln, NE: Buros Institute of Mental Meausurements.

Qian, G., & Alvermann, D. (1995). Role of epistemological beliefs and learned helplessness in secondary school students' learning science concepts from text. *Journal of Educational Psychology*, 87, 282–292.

Rothenberg, D. (1997). How the web destroys the quality of students' research papers. *Chronicle of Higher Education*, 49, A44.

Ryan, M. P. (1984). Monitoring text comprehension: Individual differences in epistemological standards. *Journal of Educational Psychology*, 76, 248–258.

Schacter, J., Chung, G., & Dorr, A. (1998). Children's Internet searching on complex problems: Performance and process analysis. *Journal of the American Society for Information Science*, 49, 840–849.

Schommer, M. (1990). Effects of beliefs about the nature of knowledge on comprehension. *Journal of Educational Psychology*, 82, 498–504.

Schommer, M., Crouse, A., & Rhodes, N. (1992). Epistemological beliefs and mathematical text comprehension: Believing it is simple does not make it so. *Journal of Educational Psychology*, 84, 435–443.

Schraw, G., Dunkle, M. E., & Bendixen, L. D. (1995). Cognitive processes in well-defined and ill-defined problem solving. *Applied Cognitive Psychology*, 9, 523–538.

Sinatra, G. M., Southerland, S. A., McConaughy, F., & Demastes, J. (2003). Intentions and beliefs in students' understanding and acceptance of biological evolution. *Journal of Research in Science Teaching*, 40, 510–528.

Stanovich, K. E. (1999). *Who is rational? Studies in individual differences in reasoning*. Mahwah, NJ: Lawrence Erlbaum.Sweller, J. (2005). Implications of cognitive load theory for multimedia learning. In R. E. Mayer (Ed.), *The Cambridge handbook of multimedia learning* (pp. 19–30). New York: Cambridge University Press.

Tsai, C. C. (2004). Beyond cognitive and metacognitive tools: The use of the Internet as an epistemological tool for instruction. *British Journal of Educational Technological*, 35, 525–536.

Windschitl, M., & Andre, T. (1998). Using computer simulations to enhance conceptual change: The roles of constructivist instruction and student epistemological beliefs. *Journal of Research in Science Teaching*, 35, 145–160.

Zhang, S., & Duke, N. K. (2005). *Strategies of Internet reading with different reading purposes*. Paper presented at the annual meeting of the American Educational Research Association. San Francisco, CA.

Chapter 19
Developing Relational Epistemology Through Relational Pedagogy: New Ways of Thinking About Personal Epistemology in Teacher Education

Joanne Brownlee and Donna Berthelsen

Abstract Personal epistemology research over the past few decades has helped us to understand better the nature of effective learning and teaching in teacher education. However, personal epistemology has been based predominantly on psychological frameworks in which knowledge and beliefs are individually constructed. In this chapter, we present a social constructivist perspective on the development of epistemological beliefs in which beliefs are constructed through interactions with social and learning contexts. We argue for the term "relational epistemology" to be used rather than "personal epistemology" to better reflect the role that external and internal relations play in the social construction of epistemological beliefs. From this framework, we then report on research into early childhood professionals' beliefs that provide new ways of thinking about the referential and structural dimensions of relational epistemology and how these might be facilitated using an extended model of relational pedagogy in teacher education.

19.1 Introduction

The student population in higher education is increasingly characterised by diversity in socio-economic backgrounds, sexual orientation, gender, ethnicity, and ability. Such diversity requires new ways of thinking about tertiary teaching that might help students to manage the complexities of an ever changing and pluralistic world (Baxter Magolda & Terenzini, 2004). Kuhn and Udell (2001) suggest the goal of higher education should be to help students deal with these complexities by teaching the tools of wisdom, which include critical thinking. An important aspect of critical thinking is that students are able to reflect on and evaluate evidence and make informed decisions in their professional work. Thus, it is important that a focus on thinking processes, not just the curriculum content, is included in higher education to help

Queensland University of Technology, Brisbane, Australia

M. S. Khine (ed.), *Knowing, Knowledge and Beliefs: Epistemological Studies across Diverse Cultures.*

students deal with ill-defined problems in complex settings. Kuhn and Udell argue that the beliefs which students hold about the nature of knowing and knowledge, known as epistemological beliefs, are the basis on which critical thinking can be promoted.

Within teacher education programmes, student teachers' epistemological beliefs are often not addressed (Nespor, 1987). In fact, teacher education has often been framed in terms of a factory model in which specific content and skills are expected to be demonstrated (Griffith & Benson, 1991). Similarly, Wood and Bennett (2000) believe that teachers' professional development has often been conceived of as a set of specific skills and competencies to be obtained at key points along a career pathway. These views do not acknowledge the importance of learning processes through which knowledge is personally constructed based on the evaluation of evidence. In teacher education programmes, it is increasingly apparent that we need to focus greater attention on the nature of beliefs of pre-service teachers that are known to influence practice (Lawrence, 1992; Pajares, 1992; Richardson et al., 1991; Wood & Bennett, 2000). Specifically, Wood and Bennett (2000) proposed that beliefs related to teachers' personal epistemology should be addressed in professional programmes. They suggested that teachers' professional learning is "inadequately theorised and there is a lack of clarity about the type of theoretical framework to guide their development" (p. 635). This chapter will theorise about teachers' professional learning using a social constructivist framework to explore new ways of thinking about personal epistemology. We then propose an approach to developing sophisticated epistemological beliefs in teacher education programmes through relational pedagogy.

19.2 Personal Epistemology

Personal epistemology refers to beliefs about knowing and knowledge at the individual level (Hofer, 2005). Kitchener (2002) described personal epistemological beliefs as "folk epistemology" or an individual's "untutored" views about the nature of knowledge (p. 89). Hofer (2005) defined personal epistemology as "an identifiable set of dimensions of beliefs about knowledge and knowing, organised as theories, progressing in reasonably predictable directions, activated in context, operating both cognitively and metacognitively" (p. 98).

Over the past few decades considerable research related to epistemological beliefs has suggested that beliefs evolve in complexity over time in the context of higher education. Personal epistemology influences a range of aspects of learning and teaching but education also influences personal epistemology (Hofer, 2004; King, & Kitchener, 2004). Early research by Perry (1970) showed that as students progressed through their university course they evidenced more sophisticated beliefs. At first, students described dualistic beliefs that reflected black and white, absolute knowledge. This absolute and categorical way of knowing meant that knowledge could simply be received from an external source without being evaluated. Once students realised that absolute truth did not exist, they came to believe that their own opinion counted as knowledge and that conflicting views of truth may be equally valid. This was referred to as multiplism. Next, with the development of relativistic beliefs came an understanding that the individual is an active maker of meaning and knowledge is complex, tentative and evolving.

Many developmental models since the 1970s suggest similar trajectories in epistemological beliefs. For example, Kuhn and Weinstock (2002) described absolutism (reality is replicated), multiplism (personal opinions) and evaluativism (evidenced-based opinions). Bendixen (2002) indicated that individuals develop from "simple dichotomous views of knowledge" to beliefs that are "postrelativistic" (pp. 191–192) or evaluativistic in nature. However, not all theories propose such stage-like, unidimensional trajectories. Schommer (1993) described epistemological beliefs as multidimensional and independent which means that individuals can simultaneously hold both sophisticated (evaluativistic) and naive (objectivist) views about the nature of knowing and knowledge. The dimensions proposed by Schommer included (a) Omniscient Authority (beliefs in the source of knowledge), (b) Certain Knowledge (beliefs in the certainty of knowledge), (c) Simple Knowledge (beliefs in structure of knowledge), (d) Quick Learning (beliefs in the speed of learning), and (e) Innate Ability (beliefs in the stability of knowledge). These beliefs do not necessarily develop in unison and variously influence approaches to learning and learning outcomes.

Epistemological beliefs may also influence approaches to teaching (Brownlee, 2001b). Chan and Elliott's (2004) research demonstrated that epistemological beliefs influence teachers' judgments about what knowledge is important in particular learning situations. These beliefs mediated how a teacher processes and retains certain information thereby influencing how they go about teaching. For example, when teachers hold predominantly objectivist beliefs and knowledge is viewed as certain, transferable and not needing to be critiqued then teaching is more likely to be teacher-centred and transmissive. Alternatively, teachers holding evaluativistic beliefs view knowledge as constructed and evidenced-based so it is more likely they will be constructivist and learner-centred in their approaches to teaching (Arredondo & Rucinski, 1996; Berthelsen et al., 2002). Moreover, such teachers are likely to engage in critical thinking that is clear and mindful of others (Kuhn & Udell, 2001).

19.3 Relational Epistemology

Theories of personal epistemology described so far have often reflected psychological frameworks (Pintrich, 2002) whereby knowledge and beliefs are individually constructed. In this section, we argue that the development of epistemological beliefs is based on a social constructivist framework in which beliefs are constructed through interactions with others in social contexts. A considerable body of current educational research uses social constructivist theories as the platform for understanding teaching and learning. These theories "focus on the interdependence of social and individual processes in the co-construction of knowledge" (Palinscar, 1998, p. 345). Using the terminology of Kang and Wallace (2005), we will argue for the term "relational epistemology" to be used rather than "personal epistemology" to better reflect the role that external (social) and internal (individual) relations play in the social construction of epistemological beliefs.

In social constructivist theory it is not possible to separate the internal from the external influences. However, it is possible to foreground one aspect whilst still being cognizant of the other (Palinscar, 1998). External relations are those that involve relationships between the self and others (including the learning environment). Internal relations are those connections made between new information to be learned and prior knowledge and beliefs. The 3 P Model of Learning proposed by Biggs (1993) can be used to inform understanding about a how epistemological beliefs are constructed through external and internal relations. Biggs's model identified three ordered sets of elements that influence individuals' learning. These are Presage factors (personal and situational), Process factors (approaches to learning) and Products (learning outcomes).

Students come to a learning experience with pre-existing epistemological beliefs, abilities, knowledge, motivations, and personality traits which are described in the Fig. 19.1 as Personal Presage Factors. These personal characteristics influence, and in turn are influenced by, situational presage factors which include social relations (engagement with peers and teacher, interpersonal climate) and learning contexts (nature of task, assessment). As a result, in any learning situation students develop a context-specific perception of a learning task. These *external* connections with the social and learning contexts influence both students' context-specific construction of knowledge and their approaches to learning (Process component of Model).

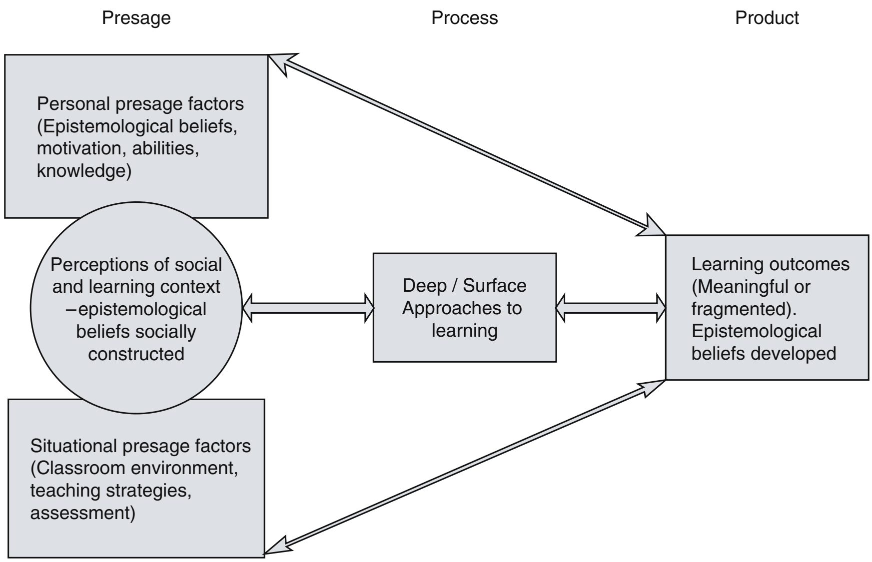


Fig. 19.1 The social construction of epistemological beliefs adapted from 3 P Model of Learning (Adapted from Biggs, 1993)

Brownlee (2001b) found that evaluativistic epistemological beliefs were related to deep approaches to learning, which require *internal* connections to be made between new information and pre-existing beliefs/knowledge. It is likely that deep approaches to learning will result in greater depth of understanding in a particular learning task and more likelihood of the development of an evaluativistic stance in the development of epistemological beliefs (Product component of the model). Students using surface approaches to learning often use repetition as a strategy to learn and are more likely to hold objectivist epistemological beliefs that focus on the reproduction of knowledge. Surface approaches to learning do not allow internal connections to be made between prior knowledge/beliefs brought to a new learning task and the new knowledge which the task was designed to achieve. Thus, learning outcomes are likely to be more superficial and fragmented and objectivist beliefs are reinforced (Product component of the model). Objectivist epistemological beliefs are still held and continue, as personal presage factors, to influence future learning.

Kang and Wallace (2005) also take a social constructivist view of epistemological beliefs by describing both internal and external relations in the construction of epistemological beliefs. They refer to epistemology as relational because of "the relationship between the knower and the known" (p. 142) which reflects the internal relations discussed earlier in this section. We would argue this might be restated as "relationships between *knowers* and the known" to capture more effectively the social nature of learning. However, Kang and Wallace also state that a particular "epistemological stance" (p. 143) is taken during the teaching–learning process as a result of existing epistemological beliefs and the specific learning context. This suggests that Kuhn and Wallace also see epistemological beliefs being constructed on the basis of external relations. Using Kang and Wallace's terminology, we argue that "personal epistemology" can be described as "relational epistemology" to reflect the role of both the external (social and learning contexts) and internal relations (individual connections between new and prior knowledge/beliefs) in the construction of epistemological beliefs.

We believe that, to date, epistemological belief research has focused on the referential or meaning of epistemology beliefs. In response to Schraw and Sinatra's (2004) and Hofer's (2005) call for research that investigates the nature of epistemological beliefs in more depth, we propose a more detailed analysis of relational epistemology. This analysis includes a focus on both the referential and structural dimensions of epistemological beliefs as a way to better understand how to promote the development of a more evaluativistic stance for students in teacher education programmes.

19.4 Referential and Structural Dimensions of Relational Epistemology

Any phenomenon, including epistemological beliefs, has both a referential (meaning) and structural (organisational) dimension according to Marton and Booth (1997). These dimensions are intertwined – meaning is dependent on structure and vice versa. Using the phenomenon of "learning" as an example, an individual might think that learning is about observation by which one learns through modelling the behaviours of others. This is the referential dimension of that phenomenon for that individual. However, in order for something to have meaning it also needs a structure. The structural aspects include different elements that contribute to the whole conception of the phenomenon, in this case, a conception of learning. For example, individuals who think learning is about observation may describe a number of facets about how observation is implicated in learning and how these facets are related. So, observation might be described as the means through which individuals make meaning from their experiences or as the sequence of actions that allows individuals to reproduce observed skills. How these different aspects of observation are related to each other might also be described. Thus, an understanding of learning has both referential and structural dimensions and these are intertwined in the manner in which any individual makes sense of the phenomenon. To date, the epistemological beliefs research has primarily focused on the referential aspects of beliefs but both the meaning and the structure need to be considered to understand relational epistemology as a phenomenon. The referential and structural dimensions of relational epistemology will now be discussed in turn.

19.4.1 Referential Dimensions of Relational Epistemology

The referential dimension of epistemological beliefs is based on the relationship between knowers and the known. This means that how we assign meaning to the different types of epistemological beliefs (e.g., objectivist, multiplist, evaluativist beliefs) is informed by the extent to which individuals consider themselves to be receivers of knowledge disconnected from the meaning-making process or active constructors of knowledge connected to the meaning-making process (Kang & Wallace, 2005). The nature of the relationship between knowers and the known is the referential basis upon which epistemological beliefs are described as relational epistemology.

Over the last decade, our research has investigated the referential dimensions of epistemological beliefs in Australian childcare workers (Brownlee et al., 2006; Berthelsen et al., 2002; Brownlee & Berthelsen, 2004, 2006; Tickle et al., 2005). Some of these beliefs are similar to those already described in the literature, namely objectivism, multiplism, and evaluativism (Kuhn & Weinstock, 2002). However, recently we interviewed 77 pre-service childcare workers completing a 2-year full-time Diploma of Children's Services. Students were interviewed about their beliefs about knowing and knowledge using a scenario about a dilemma for childcare practice based on the work of Stacey et al. (2005). The scenario was used as a concrete stimulus to enable students to reflect on their epistemological beliefs in relation to the situation described. The semi-structured questions used in the interview about the scenario related to beliefs about knowing and knowledge as described by Hofer and Pintrich (1997).

In Australia, childcare workers are trained through Institutes of Technical and Further Education (TAFE) and private providers within the Australian Vocational Training and Education (VTE) system to teach young children in long day care settings. Across many industries, vocational programmes (e.g., for childcare) are based on nationally endorsed standards for recognising and assessing students' skills. It is a Competency-Based Training (CBT) approach to vocational training that places the major emphasis on what the person can do as a result of training (the outcome). Competences are role derived, specified in behavioural terms, and the assessment of learning requires performance as the primary evidence that learning has occurred (Smith & Keating, 2003).

A number of these students revealed new ways of thinking about epistemological beliefs that have not been evident in the epistemological literature to date. In addition to the beliefs typically reported in the literature, namely objectivist and multiplist beliefs, students described *complex* and *practical evaluativism* (Brownlee et al., 2006). In complex and practical evaluativism, there was an active process of analysis based on a critique of theoretical and practical evidence respectively. Each of these forms of evaluativism will be discussed now in more detail.

Complex evaluativism describes a set of beliefs in which knowledge is conceived of as tentative, evolving, and evidenced-based. The relationship between the knower and the known is such that multiple theoretical perspectives are actively considered, compared and a critique is made in order to arrive at an informed perspective. This construction of knowledge is the basis of an informed understanding or opinion and is similar to evaluativistic (Kuhn & Weinstock, 2002), relativistic (Perry, 1981), contextual (Baxter Magolda, 1993), and constructed (Belenky et al., 1986) ways of knowing as described in the literature. For example, Amanda indicated that theoretical knowledge needed to be analysed and evaluated in order to develop her own opinions.

> I suppose probably taking on board what the experts said, having a look at another source and seeing what they've said and probably try and come up with my own understanding of what they are trying to teach me. I don't know if anyone could be an expert in the area because it is always changing. You always learn more. There is always something that they haven't thought of. (Amanda)

Students with *practical evaluativistic* beliefs indicated that multiple perspectives were actively considered, compared and evaluated. However, these perspectives were not theoretically based but related to the vocational context. This indicated that there was a meaningful relationship between the knower and the known. However, the evidence they analysed was about experts' views about strategies for practice in the childcare field. These beliefs are referred to as *practical evaluativism* because the students did not analyse knowledge to create an "informed opinion or understanding" but rather analysed strategies to develop "informed practice". For example, Ashley indicated that he would analyse experts' experiences to see what would work for him.

> (If experts disagree)… the first thing I think is what works best for me… you just read over them a lot to see where they are coming from. Kind of think of what would happen if you actually used that. And even just sometimes reading a bit more background

> towards it… And, it is just looking at what they are basing it on; just kind of look at everybody's point of view because at some point they will work because they have obviously published it. (Ashley)

These practical evaluativistic beliefs were sometimes described in terms of practices that "felt right" to the student. Other students valued a "majority rules" approach. In this approach, students considered that they would base their practice on how many experts supported a particular teaching strategy. For example, Natalie thought that knowledge could be based on the consensus between experts' opinions.

> Research a bit more and see if anyone else disagrees with them. Or raise points [on] both sides and then if this side has more arguments … but this side also could be right. I think you should research the topic through many experts and if the opinion is the same or if it's all linked then you could use it. (Natalie)

Subjectivist beliefs were also noted in our research. These students believed that knowledge comprised personal opinions that did not need to be evaluated or evidenced-based. The relationship between the knower and the known is one of being separate from the meaning-making process. These students did not engage in a critique of other perspectives to create an informed perspective. They relied on their intuitive beliefs or personal opinion. These beliefs are similar to multiplistic (Kuhn & Weinstock, 2002), multiplism (Perry, 1981), transitional (Baxter Magolda, 1993), and subjectivist (Belenky et al., 1986) ways of knowing. For example, Nerida did not believe one could question others' opinions about teaching practices in childcare because children were so individual and any opinion about best practice could be valid.

> There are no right answers in child care, because you have to get out there and find things for yourself. Once again, textbooks aren't always right. You have to find out what works for you, what works for the children. You are obviously going to clash with some people with your opinions, but you just have to, like everything, take it on board and just respect that. You might not agree with it but their opinion is valid and it is up to you whether you take it on or just take it as just their opinion. (Nerida)

Finally, students with *objectivist* beliefs, described knowledge as able to be "given" to another. These beliefs are also commonly reported in the literature. There is no need to analyse evidence, but simply accept "truths" from others. The relationship between the knower and the known is one of being a receiver of knowledge and being separate from the meaning-making process. Students believed that they could rely on being given information from experts whose knowledge they believed was "right". These beliefs are similar to absolutist (Kuhn & Weinstock, 2002), dualistic (Perry, 1981), absolute (Baxter Magolda, 1993), and received (Belenky et al., 1986) ways of knowing. Sherree exemplifies this view of knowledge and knowing:

> Sheree: Everybody needs to be qualified so that they all know the same things and not applying different ways of doing things, and because it is somebody else's children. I think be qualified, so you can provide quality care and be true to the parents.
>
> Interviewer: I just want to try and make clear the link between the qualifications and being true to yourself and to the parents. How is that related to the concept of truth?
>
> Sherree: Because you are doing things the right way. It's not necessarily truth, but you're providing quality standard of care that you are meant to.

> Interviewer: How would you consider accreditation and those sorts of things as truths or are they separate from truth?
>
> Sherree: It's because they're right, that's what child care is run on. So it's like the right way.

To summarise, the referential dimensions of epistemological beliefs can be described as relational epistemology because of the way in which knowers relate to the information to be learned (the known) in social contexts. In complex or practical evaluativism, our research has demonstrated a connection with the meaning-making process through an active process of making a critique of theoretical and practical experiences respectively. It is not surprising that practical evaluativism is evident in the responses provided by these students. They were engaged in a CBT course which was focused on demonstrating specific skill outcomes in their learning. A CBT model of training is more likely to promote a relationship between the knower and the known which is more focused on the analysis of skills and strategies rather than theoretical knowledge.

The differentiation of evaluativism into complex and practical ways of knowing may help us to consider the impact of education and training on beliefs. More research is needed to explore how teacher education programmes facilitate practical evaluativistic beliefs and to what extent these beliefs change once students engage in professional practice. Does it matter that students are evaluating practice rather than knowledge when they are engaged in practice? What implications are there for how students conceive of their own learning and children's learning at the end of their pre-service teacher education programme? These are important issues that need to be explored further in relation to the model of training and education processes that students experience.

19.4.2 Structural Aspects of Relational Epistemology

To date, research on epistemological beliefs has focused on the referential aspects but, as indicated previously, both the meaning and the structure of epistemological beliefs need to be considered to make sense of relational epistemology as a phenomenon. The structural aspects of relational epistemology are now discussed as a way to extend our understanding of the phenomenon.

In a study of pre-service teacher education students, Brownlee (2001a, 2004) analysed the structural dimensions of epistemological beliefs using the Structure of Observed Learning Outcomes (SOLO) taxonomy (Biggs & Collis, 1982). There are five levels of organisation in the SOLO taxonomy which can be used to investigate the relationships between aspects (structure) of a particular phenomenon. These are

- Prestructural organisation which reflects no understanding of the phenomenon
- Unistructural organisation in which the learner focuses on a single aspect of the phenomenon under investigation

- Multistructural organisation in which the learner shows understanding of a number of aspects of the phenomenon but does not make connections between those aspects
- Relational organisation in which individuals are able to differentiate the various aspects of the phenomenon and relate these aspects in a way that develops a coherent whole
- Extended Abstract organisation where a relational understanding of the phenomenon is able to be applied to understanding an entirely different domain of knowledge

Brownlee (2001a, 2004) found that a *Unistructural* organisation was usually evidenced by individuals who held objectivist epistemological beliefs. They described knowledge as absolute and categorical. In the following example, the student espoused beliefs about knowledge as absolute and universal. This organisation of her beliefs was consistent across the entire interview:

> Things that are pretty much laid out as in, "I believe in absolute truths"…. The best way I can give it is as an analogy – if you have a white board and you look at the white board it is white but if somebody else looks at the white board through rose coloured glasses they think it is rose where in fact it hasn't changed the fact that the white board is still white. (Brownlee, 2001a, p. 286)

Individuals with subjectivist beliefs discussed knowledge in absolute categorical terms (objectivism) and as personal opinions (subjectivism). There was no relationship evident between these sets of beliefs. This was considered as *multistructural* organisation. It was if these individuals held conflicting and separate beliefs about knowing throughout their interviews, as evident in the following example.

> I still think that there are some things that are, you know obviously true, maybe like some of the maths. Like some things are black and white but generally truth still for me comes from taking what is around you and putting your own interpretation on lots of things. So I guess you are listening to other people and making some judgements I suppose about what you believe about that. (Brownlee, 2001a, p. 286)

Finally, individuals who evidenced evaluativistic beliefs about knowledge throughout their interview often referred to a range of beliefs (evaluativism, subjectivism, and objectivism) but there was an integrating theme to their beliefs across the interview. They kept returning to the view that there was not a single reality and that reality was a personal construction based on evidence. This was a *Relational* structure in beliefs with a common theme of evaluativism.

> I think that is all tied in with my beliefs about not being an absolute right or an absolute wrong and people are entitled to their own opinions as long as their opinions are valid, are reasoned out. They are not just an opinion off the top of their head. They have actually reasoned out their opinions and said well I think it is because of such and such; so I think knowledge is a very personal thing as well. (Brownlee, 2001a, p. 286)

The phenomenon of epistemological beliefs has been described so far as relational epistemology. The referential aspect of relational epistemology reflects the relationship between the "knower and the known" (Kang & Wallace, 2005, p. 142) in which connections are made, or not, to the learning object. The structural aspect of relational epistemology reflects the extent to which the various types of epistemological beliefs are related to each other within the epistemological belief system.

19.5 Developing Relational Epistemology Through Relational Pedagogy

Using this understanding of the meaning and structure of epistemological beliefs, how can we promote the development of relational epistemologies in students who are participating in pre-service teacher education courses? Such epistemologies are likely to result in more effective learning outcomes for these students as a result of their studies which, in turn, will promote better quality of practice in their future work with their own students. Teaching in higher education programmes needs to promote stronger connections between "the knower" and their existing beliefs and "the known" through internalisation of new knowledge that is evaluated and understood in a critical way. This involves active meaning-making through weighing available evidence in a knowledge domain in order to arrive as a personally reasoned stance about the knowledge that will be used to inform professional practice. Educators in tertiary education programmes who are preparing pre-service teachers for their professional work can facilitate relational epistemologies through strategies proposed by Baxter Magolda and Terenzini (2004) that include:

- Modelling an informed critique of knowledge and how evidence can be weighed
- Assisting students to practise their skills for evaluating knowledge in a collaborative learning community
- Explicitly acknowledging and being inclusive of the complexity and subjectivity of knowledge

Such active and socially constructed processes to teaching in higher education programmes require encouragement to students to:

- Reflect on their personal experiences
- Explore new ideas in a critical way
- Integrate new understandings into their existing beliefs and knowledge
- Practise using new knowledge in their professional training course

These processes are elements of what Baxter Magolda (1996) described as relational pedagogy where self and theory are interconnected. Such constructivist approaches to teaching in professional higher education programmes support the development of evidenced-based epistemologies by helping students connect and make a critique of personal experiences and theoretical knowledge (Baxter Magolda, 1993). To help students to develop such relational epistemology, educators in professional programmes must value and respect learners' prior knowledge and their style of learning (King & Kitchener, 1994), as well as supporting students to make new links between theory and personal experience.

In summary, relational pedagogy can engage students to move towards more evaluativistic thinking as they learn that knowledge is constructed through making a critique of theoretical knowledge and understanding links between their current and previous experiences. It is relational in the sense that it focuses on both a respectful *external* relationships between teacher and student and an *internal* knower–known relationship of "connecting the self to the knowledge construction process" (Kang & Wallace, 2005, p. 142). The external and internal relationships described earlier in regard to relational epistemology are supported through the focus on external and internal connections in a relational pedagogical approach.

The concept of relational pedagogy will now be extended to include epistemological beliefs reflection (both explicit and implicit) and the development of critical inquiry skills as part of a relational pedagogical approach to teacher education.

19.5.1 Epistemological Beliefs Reflection in Relational Pedagogy

Within an approach to teaching based on relational pedagogy, we advocate for an explicit and implicit focus on epistemological beliefs to promote effective learning. There is a substantial body of research that suggests that interventions which focus *explicitly* on the referential elements by engaging students in a process of reflection on their own beliefs may assist in the development of epistemological beliefs (Brownlee et al., 2001; Cano, 2005; Lyons, 1990; McLean, 2001; Nist & Holschuh, 2005; Schommer, 1994; Stacey et al., 2005). Students "who demonstrate more naive core beliefs about knowing on entry into tertiary studies may need individual instruction in the nature of knowledge, as well as study strategies. For the majority of students, epistemological instruction incorporated within first-year introductory courses is likely to enhance their outlook on the nature of knowledge and learning" (Schommer & Walker, 1997, p. 184). It is important for students to understand that sometimes evidenced-based thinking is needed to think critically and deal with ill-defined problems (Kardash & Scholes, 1996; Kuhn & Udell, 2001).

While some research suggests that explicit reflection may be productive in developing epistemological beliefs, to date there have been no reports of interventions which have also encouraged explicit reflection on the structural aspects of epistemological beliefs. This means that, in order to develop relational epistemology, teacher educators may need to encourage students to explicitly reflect, not only on the referential nature of their beliefs, but also on how a range of beliefs might be related (Brownlee, 2001a). For example, how many different types of beliefs about knowing and knowledge do the students hold and what is the focus of their beliefs? Are there structural relationships between the beliefs? Are there themes that connect these beliefs?

Relational epistemological beliefs can also be influenced by an *implicit* or indirect focus on epistemological beliefs. This involves the use of assessment and teaching strategies that encourage students to engage in approaches to learning that are reflective of sophisticated beliefs. Such indirect approaches rely on how teacher educators themselves conceive of knowing and knowledge. Schommer-Aikens (2004) suggested that teachers' epistemological beliefs influence the nature of teaching and assessment and subsequently the development of their students' beliefs. For example, if a teacher with evaluativistic beliefs uses assessment and curriculum that require students to integrate and make a critique of knowledge, students may come to understand that knowledge is tentative and uncertain and must be evaluated. Thus, students may take on a particular "epistemological stance" (Kang & Wallace, 2005, p. 143) based on experiences within the learning context in which they are participants.

Brownlee et al. (2001) implemented a teaching programme designed to focus implicitly and explicitly on the development of epistemological beliefs. Twenty-nine graduate pre-service teacher education students completed a year-long unit on educational psychology. Apart from explicit reflection on the nature of beliefs through the use of journals and interviews, an implicit focus was created through the use of integrated curriculum. The educational psychology content was integrated using epistemological belief theory. For example, students discussed the topic of behaviour guidance from a range of different theoretical perspectives but also considered how a teacher's epistemological beliefs might influence how they guided children's behaviour in the classroom. This process took place for all topics covered in the subject. An integrated view of knowledge for the course content was therefore provided by encouraging students to link tutorial content to an epistemological beliefs framework. This was described as a *relational curriculum* (Brownlee, 2004) and was used as a way to indirectly model sophisticated views about knowing and knowledge.

19.5.2 Skills of Critical Inquiry in Relational Pedagogy

Baxter Magolda and Terenzini (2004) suggest that, apart from encouraging students to reflect on their epistemological beliefs, students need to be supported to practise the skills needed to reflect in an epistemologically sophisticated way. These include strategies to search for relevant information and select, analyse, and weigh the evidence from different sources to develop reasoned responses, rather than relying on personal opinions or accepting experts' views uncritically. Effective, relational pedagogy needs to focus on both *beliefs* (referential and structural dimensions) and incorporate *strategies* that are likely to enhance the development of a relational epistemology.

Stacey et al. (2005) developed an intervention that was designed to focus on beliefs and the strategies associated with relational epistemology. Students in their third year of a 4-year Bachelor of Education (Early Childhood) programme undertook a compulsory research methods unit specifically designed to develop epistemological beliefs. The unit covered a range of topics related to research knowledge and skills (e.g., research paradigms, data collection techniques, data analysis strategies, assessment of the validity and trustworthiness of data, and conducting literature reviews in a knowledge domain). The assessment approach within the unit of study was a formative and summative report on a small scale research study that encouraged students to develop skills for critical analysis of evidence. In the research study, students interviewed a critical friend about their epistemological beliefs at the beginning and end of the semester-long unit. Stage 1 of the report was essentially a research proposal that required the submission of a critical literature review (drawing on theory and research related to epistemological beliefs and teacher education) and a methods section. Stage 2 was the final research report that required a revised literature and method sections (after feedback from lecturers) as well as the analysis of the findings from the student interviews.

All students completed the Epistemological Beliefs Questionnaire (EBQ) (Schommer, 1998) at the beginning and end of the semester. The analysis of belief change from the beginning to the end of the semester indicated that students were more likely at the end of their course to see knowledge as integrated and related to effort rather than dependent on innate ability. They were more likely to believe that a critique can be made of experts' knowledge. The study showed that explicit reflection on epistemological beliefs and a structured approach to developing the skills needed for critique of evidence assisted students to develop more relational epistemological beliefs. More research is needed, to determine how explicit reflection and skill development contributes to changes in epistemological beliefs.

19.6 Towards an Extended Model of Relational Pedagogy in Teacher Education

A common goal for teacher education is to assist teacher education students to be able to enact sophisticated relational epistemology in diverse and often complex teaching and learning environments. To promote belief change, pre-service teacher education students need to be able to explore and articulate their personal beliefs about teaching and learning that may have been developed prior to their entry into their higher education programme. They need to be supported to become critical thinkers by developing the skills to evaluate different sources of evidence stemming from the theory and research (Kuhn & Udell, 2001). We need to change our approach to teacher education so that it reflects relational pedagogy. With an explicit and implicit focus on epistemological beliefs and skills, relational pedagogy holds promise as a conceptual platform on which to base future research on the outcomes of teacher education programmes.

An extended model of relational pedagogy for teacher education is presented in Fig. 19.2. It provides a description of how relational pedagogy can promote relational epistemology using a social constructivist theory. From this perspective, epistemological beliefs are constructed in a social context, rather than as an individual process of construction of meaning. This model evolved by first adapting the 3 P Model of Learning (Biggs, 1993) to apply to teaching, which resulted in the *Relational Model of Teaching* (Brownlee, 2004). The Model was then further

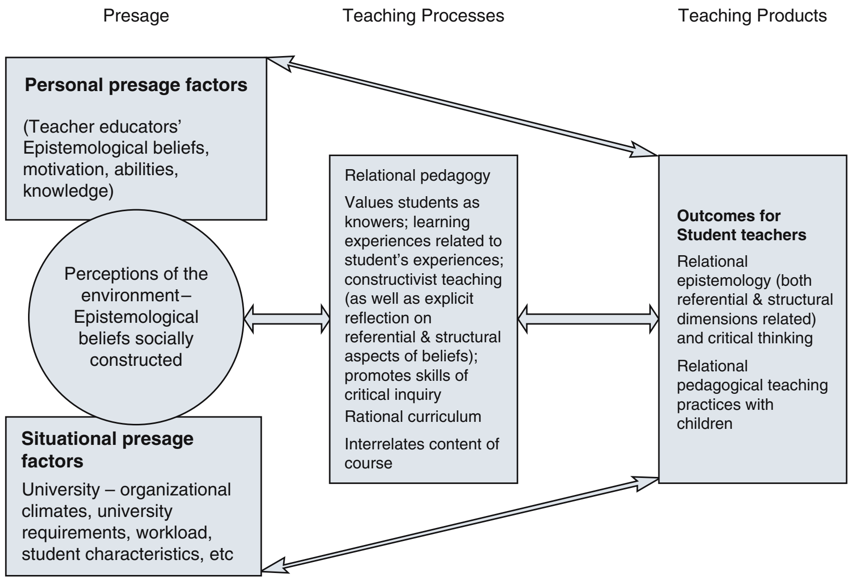


Fig. 19.2 Model of relational pedagogy in teacher education (Adapted from Brownlee, 2004 and Biggs, 1993)

extended by incorporating skills for critical inquiry as an important aspect of relational pedagogy (the Process component of the model).

In this extended model, Relational pedagogy (Process component of model) draws on the constructivist teaching approaches originally described by Baxter Magolda (1996) in which students' beliefs are respected in the learning context and learning experiences are connected to prior experiences in a social context. However, we have also argued that relational pedagogy should include explicit reflection on referential and structural aspects of beliefs as well as the use of an implicit focus on epistemological beliefs through relational curriculum (Brownlee, 2004).

Relational pedagogy is influenced by personal and situational presage factors, as indicated in the Model. Teacher educators' own beliefs are acknowledged as an important presage factor, in addition to other factors such as knowledge, abilities, motivations, etc. Their work context can facilitate or impede the implementation of relational pedagogical approaches in higher education programmes. Situational presage factors, such as expectations of their students and characteristics of the students, as well as the organisational and cultural climate of their work setting impact on their own epistemological development (Personal presage factor) and subsequently how their beliefs are enacted in practice (Process: Teaching approach). For example, a teacher educator with more sophisticated epistemological beliefs and a knowledge of constructivist teaching strategies (Personal presage factor) who interacts in a university culture of support and innovation (Situational presage factors) is more likely to enact evaluativistic epistemological beliefs and be able to engage in relational pedagogy and curriculum (Process: teaching approach). Relational pedagogy and curriculum are likely to result in stronger learning outcomes for student teachers (Products: professional practice outcomes) that include the development of a relational epistemology to inform their professional practice in the future (becomes a Personal presage factors for future learning).

19.7 Conclusion

This paper has argued for personal epistemological beliefs to be considered as relational epistemology and for the development of such beliefs through the implementation of relational pedagogy in teacher education. The argument is made that quality teacher education courses should support teaching and learning processes in higher education through explicitly and implicitly addressing epistemological belief and strategy change. The conceptualisation presented proposes a theoretical shift from the individualistic view of personal epistemology to a social constructivist view of epistemological beliefs which links internal and external relations. The paper presented a view of learning in relation to change in epistemological beliefs drawing on the 3 P Model of Learning proposed by Biggs (1993), as well as drawing on this model to develop a model for relational pedagogy that is socially and contextually situated.

A process of change in teachers' thinking about their practice is required by the increasing recognition that teaching is a complex and multifaceted process. Teacher education courses need to stimulate reflective and critical thinking about practice as necessary preconditions for effective learning outcomes. Better learning outcomes for students in teacher education courses ultimately lead to better learning outcomes for children in classrooms. Greater importance needs to be attached to the need for pre-service teacher education students to articulate and develop their theories and beliefs about teaching and learning through their course of study and become critical and reflective thinkers in their professional practices.

References

Arredondo, D. E., & Rucinski, T. T. (1996, November). *Epistemological beliefs of Chilean educators and school reform efforts*. Paper presented at the Tercer Encuentro National de Enfoques Cognitivos Actuales en Educacion. Santiago, Chile.

Baxter Magolda, M. B. (1993, April). *The convergence of rational and interpersonal knowing in young adults' epistemological development*. Paper presented at the Annual meeting of the American Research Association, Atlanta, GA.

Baxter Magolda, M. B. (1996). Cognitive learning and personal development: A false dichotomy. *About Campus*, 16–21.

Baxter Magolda, M., & Terenzini, P. (2004). *Learning and teaching in the 21st century: Trends and Implications for practice*. American College Personnel Association. Retrieved, October 5, 2004, from http://www.acpa.nche.edu/srsch/magolda_terenzini.html.

Belenky, M. F., Clinchy, B. M., Goldberger, N. R., & Tarule, J. M. (1986). *Women's ways of knowing: The development of self, voice and mind*. New York: Basic Books.

Bendixen, L. (2002). A process model of epistemic belief change. In B. Hofer & P. Pintrich (Eds.), *Personal epistemology: The psychological beliefs about knowledge and knowing* (pp. 192–205). Mahwah, NJ: Lawrence Erlbaum.

Berthelsen, D., Brownlee, J., & Boulton-Lewis, G. (2002). Caregivers' epistemological beliefs in toddler programs. *Early Child Development and Care*, 172, 503–516.

Biggs, J. B. (1993). From theory to practice: A cognitive systems approach. *Higher Education Research and Development*, 12, 73–85.

Biggs, J. B., & Collis, K. F. (1982). *Evaluating the quality of learning: The SOLO taxonomy (Structure of Observed Learning Outcomes)*. New York: Academic Press.

Brownlee, J. (2001a). Epistemological beliefs in pre-service teacher education students. *Higher Education Research and Development*, 20(3), 281–291.

Brownlee, J. (2001b). Knowing and learning in teacher education: A theoretical framework of core and peripheral epistemological beliefs. *Asia Pacific Journal of Teacher Education & Development*, 4(1), 167–190.

Brownlee, J. (2004). An investigation of teacher education students' epistemological beliefs: Developing a relational model of teaching. *Research in Education*, 72, 1–18.

Brownlee, J., & Berthelsen, D. (2004). Working with toddlers in child care: Personal epistemologies and practice. *European Early Childhood Education Research Journal*, 12(1), 55–70.

Brownlee, J., & Berthelsen, D. (2006). *Developing an extended framework for examining personal epistemology in child care training*. Unpublished manuscript.

Brownlee, J., Boulton-Lewis, G., & Berthelsen, D. (2006). *Epistemological beliefs in child care: Implications for vocational training and course design*. Unpublished manuscript.

Brownlee, J., & Berthelsen, D. (2006). Personal epistemology and relational pedagogy in early childhood teacher education programs. *Early Years: An International Journal of Research*, 26(1), 17–29.

Brownlee, J., Purdie, N., & Boulton-Lewis, G. (2001). Changing epistemological beliefs in pre-service teacher education students. *Teaching in Higher Education*, 6(2), 247–268.

Chan, K. W., & Elliott, R. G. (2004). Relational analysis of personal epistemology and conceptions about teaching and learning. *Teaching and Teacher Education: An International Journal of Research and Studies*, 20, 8, 817–831.

Griffith, B. E., & Benson, G. D. (1991, April). *Novice teachers' ways of knowing*. Paper presented at the Annual Meeting of the American Educational Research Association, Chicago, IL.

Hofer, B. (2004). Introduction: Paradigmatic approaches to personal epistemology. *Educational Psychologist*, 39(1), 1–3.

Hofer, B. (2005).The legacy and challenges: Paul Pintrich's contributions to personal epistemology research. *Educational Psychologist*, 40(2), 95–105.

Hofer, B., & Pintrich, P. R. (1997). The development of epistemological theories: Beliefs about knowledge and knowing and their relation to learning. *Review of Educational Research*, 67(1), 88–144.

Kang, N., & Wallace, C. S. (2005). Secondary science teachers' use of laboratory activities: Linking epistemological beliefs, goals, and practices. *Science Education*, 89(1), 140–165.

Kardash, C. M., & Scholes, R. J. (1996). Effects of preexisting–existing beliefs, epistemological beliefs and need for cognition on interpretation of controversial issues. *Journal of Educational Psychology*, 88(2), 260–271.

King, P., & Kitchener, K. (2004). Reflective judgment: Theory and research on the development of epistemic assumptions through adulthood. *Educational Psychologist*, 39(1), 5–18.

King, P. M., & Kitchener, K. S. (1994). *Developing reflective judgment: Understanding and promoting intellectual growth and critical thinking in adolescents and adults*. San Francisco, CA: Jossey-Bass.

Kitchener, R. (2002). Folk epistemology: An introduction. *New Ideas in Psychology*, 20, 89–105.

Kuhn, D., & Udell, W. (2001). The path to wisdom. *Educational Psychologist*, 36(4), 261–264.
Kuhn, D., & Weinstock, M. (2002). What is epistemological thinking and why does it matter? In B. Hofer & P. Pintrich (Eds.), *Personal epistemology: The psychological beliefs about knowledge and knowing*. Mahwah, NJ: Lawrence Erlbaum.
Lawrence, C. L. (1992, April). *Preservice teachers' development of pedagogical understandings and epistemological frameworks*. Paper presented at the Annual Meeting of the Educational Research Association, San Francisco, CA.
Lyons, N. (1990). Dilemmas of knowing: Ethical and epistemological dimensions of teacher's work and development. *Harvard Educational Review*, 60(2), 159–180.
Marton, F., & Booth, S. (1997). *Learning and awareness*. Mahwah, NJ: Erlbaum.
McLean, M. (2001). Can we relate conceptions of learning to student academic achievement? *Teaching in Higher Education*, 6(3), 399–413.
Nespor, J. K. (1987). The role of beliefs in the practice of teaching. *Journal of Curriculum Studies*, 19(4), 317–328.
Nist, S., & Holschuh, J. (2005). Practical applications of the research on epistemological beliefs. *Journal of College Reading and Learning*, 35, 2, 84–92.
Pajares, M. F. (1992). Teacher's beliefs and educational research: Cleaning up a messy construct. *Review of Educational Research*, 62(3), 307–332.
Palincsar, A. S. (1998). Social constructivist perspectives on teaching and learning. *Annual Review of Psychology*, 49, 345–75.
Perry, W. G. (1970). *Forms of intellectual and ethical development in the college years*. New York: Holt (Rinehart and Winston).
Perry, W. G. (1981). Cognitive and ethical growth: The making of meaning. In A. W. Chickering (Ed.), *The modern American college* (pp. 76–116). San Francisco, CA: Jossey-Boss
Pintrich, P. (2002). Future challenges and directions for theory. In B. Hofer & P. Pintrich (Eds.), *Personal epistemology: The psychological beliefs about knowledge and knowing* (pp. 389–414). Mahwah, NJ: Lawrence Erlbaum.
Richardson, V., Anders, P., Tidwell, D., & Lloyd, C. (1991). The relationship between teachers' beliefs and practices in reading comprehension instruction. *American Educational Research Journal*, 28(3), 559–586.
Schommer, M. A. (1993). Epistemological development and academic performance among secondary schools. *Journal of Educational Psychology*, 85(3), 406–411.
Schommer, M. A. (1994). Synthesising epistemological belief research: Tentative understandings and provocative confusions. *Educational Psychology Review*, 6(4), 293–319.
Schommer, M. A. (1998). The influence of age and schooling on epistemological beliefs. *British Journal of Educational Psychology*, 68, 551–562.
Schommer, M. A., & Walker, K. (1997). Epistemological beliefs and valuing school: Considerations for college admissions and retention. *Research in Higher Education*, 38(2), 173–185.
Schommer-Aikens, M. (2004). Explaining the epistemological belief system: Introducing the embedded systemic model and coordinated research approach. *Educational Psychologist*, 39(1), 19–29.
Schraw, G., & Sinatra, G. (2004). Epistemological development and its impact on cognition in academic domains. *Contemporary Educational Psychology*, 29(2), 95–102.
Smith, E., & Keating, J. (2003). *From training reform to training packages*. Tuggerah, NSW: Social Science Press.
Stacey, P. S., Brownlee, J., Thorpe, K., & Class EAB016 (2005). Measuring and manipulating epistemological beliefs in early childhood pre-service teachers. *International Journal of Pedagogies and Learning*, 1, 6–17.
Tickle, E. L., Brownlee, J., & Nailon, D. (2005). Personal epistemological beliefs and transformational leadership behaviours. *The Journal of Management Development*, 24(8), 701–719.
Wood, E., & Bennett, N. (2000). Changing theories, changing practice: Exploring early childhood teachers' professional learning. *Teaching and Teacher Education*, 16, 635–647.

Chapter 20
Knowledge and Epistemological Beliefs: An Intimate but Complicate Relationship

Rainer Bromme[1], Dorothe Kienhues[1], and Elmar Stahl[2]*

Abstract It is widely assumed that more sophisticated epistemological beliefs improve learners' understanding and knowledge. Nevertheless, recent findings challenge the idea of a simple relationship between the quality of epistemological beliefs and knowledge. For example, there is some evidence that the amount of knowledge with regard to different topics and the quality of epistemological beliefs is correlated negatively. Furthermore, gaining factual knowledge sometimes results in less sophisticated epistemological beliefs. These findings point to the question what makes up sophisticatedness and how it is related to knowledge about a certain discipline? In other words, which kinds of knowledge are necessary for the development of a sophisticated standpoint?

We claim that sophisticated epistemological judgments are generated with regard to a specific discipline or a specific topic, and that these judgments depend on individuals' personal knowledge about the production, justification and use of knowledge in a certain society but also on their ontological assumptions about a specific discipline and their topic-related knowledge. We will discuss consequences of this claim for conceptualizing and measuring epistemological beliefs.

20.1 Two Vignettes

The layperson looking for health-related information. *Robert has watched a television program on health issues and is now wondering whether it is really necessary for him to give up butter in order to avoid a heart attack. In the television show different experts (a biologist, a physician, a nutrition specialist, a health educator) had argued very controversially with regard to the dangerousness of cholesterol in*

[1] *Westfaelische Wilhelms University of Münster, Münster, Germany*

[2] *Freiburg University of Education, Freiburg, Germany*

* All authors contributed equally to the preparation of this chapter.

M. S. Khine (ed.), *Knowing, Knowledge and Beliefs: Epistemological Studies across Diverse Cultures.*

general and to the eating of butter in particular. While they all seemed to agree that there is something like cholesterol in the blood, there was no agreement which level would be dangerous. Furthermore, there was no agreement with regard to the relationship between eating butter and cholesterol level at all. Robert had not understood all arguments of these experts. "Well," he thought, "I have to make up my own mind about which of these assertions are true and which are wrong." Therefore he searched the Internet for valid information about these issues. It was not difficult to find web pages about the issues he was interested in, but swiftly he had to realize that the controversial discussion he had just watched on TV was only a foretaste of the complexity of the problem he had to deal with. He came across several web pages with clear recommendations about the dangerousness as well as about the harmlessness of eating butter, and about the importance as well as the unimportance of cholesterol for the risk of suffering from a heart attack. It turned out to be very difficult to come to any comprehensive conclusion about the general relationship between nutrition, cholesterol and cardiovascular diseases. And it was even more difficult to come to a conclusion about his own future behavior. Robert realized that any personal conclusion would be based on a foregoing assessment about the validity of the assertions he had read.

He concluded that he must find out which expert he could trust. Finally he gave up – now being very hungry – and prepared a yummy, buttered sandwich.

The biology student learning from textbooks and notes from lectures. *Anne is preparing herself for the final tests in two courses. The first course covered the vascular system and its regulation, nutrition and risks, the second course was on research methods and history of biology. She was especially lucky with that BA program of her university, because the courses were fairly integrated: the teacher of the methods and history of science course had used the recent history of theories about vascular regulation in order to exemplify the progress and change of modern biology and medicine. Nevertheless, Anne felt some contradictions between the two courses. While it was common and viable in the physiology course to think about vascular regulation, blood pressure regulation, or cholesterol as facts undoubtedly given in the textbook, it was emphasized in the history of science course that some of these concepts were mere "constructions," continuously evolving, and that their implications for the understanding of health were very controversial. Anne started to differentiate between the courses: within the history of science course she wrote and talked about that fragility of biological knowledge. In the other course, her views about concepts like "cholesterol," "vascular system" and further body functions became more and more robust against doubts. This view was all the more corroborated by her lab experience where she had done several measurements which – in her view – produced clear evidence about the measurability and certainty of these concepts.*

Robert and Anne represent persons who are confronted with situations that involve epistemological beliefs and epistemological judgments. Robert is located in an informal learning context. He starts with a question that is *related to knowledge in medicine and gets more and more confused about the nature of knowledge in medicine. His confusion is related to his own (minor) knowledge about the body functions, the credibility of experts in the field and the nature of knowledge and knowing in medicine in general.*

Anne is in a formal learning context. She gains knowledge about the topic "cardiovascular system" and – within the history of science course – about the epistemology of biological knowledge. This results in a conflict between all the (certain) facts and her experiences with the accuracy of measurements in modern labs on the one hand and the implications from the history course on the other hand. Again, her conflict is related to her own (growing) knowledge about biology, the credibility of experts (from the lab and the history course) and the nature of knowledge and knowing in biology in general. Note that both think about the same topic (the cardiovascular system), but that they construe this topic within the framework of different disciplines. Furthermore, it is important to keep in mind that one of the problems Robert has to solve concerns the relationship between topic and discipline: who (an expert in biology, in medicine, in health education) would be a reliable source? Both, Robert as well as Anne cannot collect direct evidence on their own in order to judge about the issues they are interested in. Instead they have to base their judgments on evidence provided by others: They have to confide in experts. We will refer to this aspect as "division of cognitive labor," and we will argue that this division has been mostly neglected in research on epistemological beliefs.

This chapter deals with the complex interactions between epistemological beliefs and epistemological judgments on the one hand and knowledge about specific topics (which is organized and taught within specific disciplines[1]) on the other hand.

In section 20.2 we outline research on the relationship between epistemological beliefs and topic-related knowledge. This research is mostly based on the general assumption that more sophisticated epistemological beliefs are related to more knowledge and therefore to a better understanding of the world. While there is evidence for such an assumption there are also several studies indicating a more complicate relationship. The acquisition of knowledge in a certain discipline sometimes comes along with less sophisticated epistemological beliefs. In section 20.3 we are going to present reasons for these heterogeneous results. We argue that topic-related knowledge as well as ontological knowledge has to be taken into account. We claim in the following paragraph (section 20.4) that "sophisticatedness" should be understood as "flexibility" of epistemological judgments toward both different disciplines and different contexts. This view implies the question how the cognitive system might be able to allow for such flexibility. We will outline the generative nature of epistemological judgments with reference to theoretical frameworks on

[1] We use the term "discipline" instead of "domain" to clarify that we refer to academic fields. The problematic use of the complex term "domain" has been comprehensively discussed by Hofer (2006) and by Limon (2006). Furthermore, we use the term "topic-related knowledge" instead of "discipline-specific knowledge" or "domain-specific knowledge" in order to emphasize that "topics" (e.g., the cardiovascular system) could be assigned to different disciplines (e.g., medicine and biology).

the connectionist architecture of the cognitive system as a possible answer (section 20.5). In section 20.6 we focus on the division of cognitive labor, an aspect often neglected in research on epistemological beliefs. We finish the chapter with a short summary of the main ideas and implications for research (section 20.7).

20.2 The Relationship Between Topic-Related Knowledge and Epistemological Beliefs

A growing amount of research has been carried out to link epistemological beliefs to various aspects of learning. As evidenced by a large number of empirical studies, more sophisticated epistemological beliefs are related to more adequate learning strategies and therefore better learning outcomes. For example, epistemological beliefs influence students' processing of information (Kardash & Scholes, 1996; Mason & Boscolo, 2004; Ryan, 1984; Schommer, 1990; Stathopoulou & Vosniadou, in press).

To detail, Mason and Boscolo (2004) investigated the influence of high school students' epistemological understanding on the critical interpretation of a dual-position text. Beforehand, participants' epistemological understanding was assessed using the instrument of Kuhn et al. (2000). Overall values were used to build three groups of different epistemological positions, indicating whether participants primarily hold a less advanced, moderate or more advanced view. All students read a scientific text about genetically modified food, introducing both the position in favor of and against this kind of food. After reading the text, participants were asked to write a conclusion to the text. Findings revealed that both students with more advanced beliefs and students with moderate epistemological understanding reflected better on the inconclusive nature of the debate on transgenic food, as they for example pointed out that more scientific studies on the topic are needed.

Stathopoulou and Vosniadou (in press) explored the relationship between physics-related epistemological beliefs and physics understanding of Greek secondary school students. A discipline specific instrument (Greek Epistemological Beliefs Evaluation Instrument for Physics) was administered to 394 students, out of whom 10% of students with the highest and 10% with the lowest scores were selected. These students' conceptual understanding of Newton's laws was assessed through a multiple-choice instrument. As hypothesized, epistemological sophistication in physics was found to be a predictor of conceptual understanding in physics. All students who showed a deeper understanding of Newtonian dynamics were students with highly sophisticated beliefs.

Focusing on beliefs in the certainty of knowledge, Trautwein and Lüdtke (in press, a) found them to be a significant predictor of the final school grade.

Beyond these studies described above several other studies confirm the relationship between epistemological beliefs and different aspects of the learning process. To add some more examples: college students' epistemological beliefs influence conceptual change (Qian & Alvermann, 2000; Sinatra & Pintrich, 2003), cognitive processes during learning (Kardash & Howell, 2000), learning processes within computer-based scenarios and with the Internet (Windschitl & Andre, 1998; Hofer, 2004; Tsai & Chuang, 2005), ill-defined problem-solving (Schraw et al., 1995), learning processes in hypermedia learning environments (Hartley & Bendixen, 2003; Jacobson & Spiro, 1995; Jacobson et al., 1996), and help-seeking processes in hypermedia learning environments (Bartholomé et al., 2006; Bromme & Stahl, 2003). Further on, effects of epistemological beliefs were found in different discipline like mathematics (De Corte et al., 2002; Muis, 2004; Op't Eynde et al., 2006) or history (Buehl & Alexander, 2005; Limon, 2005).

To sum up, there are indeed a lot of empirical studies pointing out that more advanced epistemological beliefs are related to better learning. Most of the studies have a correlative design and thereby imply a – more or less – linear relationship between more knowledge on the one hand and more sophisticated beliefs on the other hand.

However, several findings challenge the idea of a linear relationship between the quality of epistemological beliefs and the learning process. Several studies indicate that gaining more knowledge sometimes results in less sophisticated epistemological beliefs. To give some examples: In the context of the third international mathematics and science study (TIMSS), Köller et al. (2000) investigated physics-specific epistemological beliefs of 15- to 19-year-old students with regard to the course on physics they have chosen (an advanced course, a basic course, or no course (students in Germany can deselect some courses during their last years in high school)). On the basis of existing instruments (Labudde, 1998; Schommer, 1990), a questionnaire including five subscales (e.g., scales referring to the certainty of knowledge and simple knowledge) was designed and administered to the students. The most interesting finding is that the physical worldview of the students differed due to the kind of course chosen. A MANOVA revealed significant differences: the longer and more intensive students learnt about physics, the more they believed in dualistic views, and the more they thought that absolute "truth" can be reached in physics.

Redish et al. (1998) also focused on students' beliefs about physics. They administered the Maryland Physics Expectations survey (MPEX) at the beginning of an introductory physics course and again at the end of the course. The MPEX probes a combination of students' epistemological beliefs and their course-specific expectations and study habits. All in all, instruction caused deterioration rather than an improvement of student expectations. Before instruction, the undergraduates' answers could be rated as advanced about 50–60% of the time (e.g., they answered that physics needs to be considered as a connected, consistent framework). However, the overall percentage of sophisticated responses substantially decreased at the end of the semester, indicating that again gaining more knowledge resulted in less advanced epistemological beliefs.

A similar effect of increased knowledge on epistemological beliefs is also pointed out by Trautwein and Lüdtke (in press, b). In evaluating theory-specific epistemological beliefs, they found that students judged theories they dealt with during classes, and therefore were more familiar with, less critically than theories they knew less.

Maggioni et al. (2004) explored the influence of a professional development program for the teaching of American history on teachers' epistemological beliefs. Using epistemological profiles which enabled to assign the teachers to four different categories (criterialists, relativists, naive realists, and dichotomous thinkers), they found that movements across these different epistemological positions were not unidirectional. Before the intervention, 37 teachers were assigned to the criterialists group, which is seen to represent reflective thinking best, while 35 teachers hold a relativist position (the other two profiles did not emerge in the data). After the treatment, five teachers moved form a relativist stance to a criterialist viewpoint. But on the other hand, 13 teachers moved from the criterialist to the relativist group. Maggioni et al. therefore conclude that the development of historical thinking does not occur in a rigid, stepwise manner.

In a study on the impact of learner characteristics on students' information utilization strategies, cognitive load, and problem-solving performance in a hypermedia environment, Scheiter et al. (2007) identified five different groups of students according to their learner characteristics by means of a cluster analysis. Interestingly, learners in Cluster 4 showed significantly higher prior knowledge than learners in Cluster 5, but were more convinced that knowledge is acquired in an all-or-non-fashion compared to Cluster 5.

In our own research (Kienhues et al., in press) we found that gaining more knowledge about a specific topic can provoke less advanced epistemological beliefs. We investigated the potential for influencing epistemological beliefs about genetics through a short instructional intervention, inspired by intervention strategies developed in the context of research on conceptual change. Based on an initial survey, two groups of university students were selected, one with less advanced epistemologies and the other with more advanced beliefs. A test in prior knowledge showed that both groups had little knowledge in the topic of genetics. The participants (n = 58) were randomly assigned to different conditions: one group whose epistemological beliefs were challenged through a refutational epistemological instruction, which focused on the uncertainties and difficulties in DNA fingerprinting, or another group who received a non-challenging informatory instruction outlining facts on DNA fingerprinting. The treatment effect was assessed by comparing pre-instructional and post-instructional measures, using an instrument that convincingly measures evaluative aspects of discipline-specific epistemological beliefs (CAEB, Stahl & Bromme, in press). Even though the less advanced group receiving the refutational epistemological instruction changed toward a desirable more advanced view, the more advanced group which received the informatory instruction and therefore gained more factual knowledge, changed toward a more naive view. We were able to replicate comparable findings in two other studies.

To sum up, all empirical evidence indicates that epistemological beliefs and topic-related knowledge are closely intertwined. In the following chapter we will try to disentangle this relationship in order to explain the mixed and sometimes puzzling results described so far.

20.3 Reasons for Heterogeneous Results: The Role of Knowledge

The heterogeneous results on the relation between epistemological beliefs and knowledge described above are at least to some degree a matter of methodological heterogeneity. In the different studies, different measures for epistemological beliefs as well as for knowledge were used. For example, in some studies discipline-specific beliefs were assessed (De Corte et al., 2002; Redish et al., 1998), while general epistemological beliefs were the focus of other studies (Mason & Boscolo, 2004; Schraw et al., 1995). Knowledge was measured through multiple-choice instruments (Stathopoulou &Vosniadou, in press; Kienhues et al., in press) or just inferred from the course participants had attended (e.g. Köller et al., 2000).

However, the heterogeneity of results is not only caused by methodological heterogeneity. In our view, it is also caused by the fact that there is no linear relationship between the amount of knowledge on a certain topic and epistemological judgments about knowledge claims with regard to that topic. In the following, we will discuss which kinds of knowledge are important and how much knowledge is necessary to take up a stance that is commonly understood as sophisticated.

Among others (King & Kitchener, 2002; Richter, 2003; Trautwein & Lüdtke, in press, b), we assume that epistemological beliefs in their very core always refer to the question of certainty (or validity, viability, truthfulness) of assertions about certain topics (in other words: about the natural as well as the cultural "reality"). Science and humanities are complex systems designed for the production, justification and distribution of such assertions. Judgments about the "truth" of such assertions make up the core of epistemological judgments.[2]

Now consider Robert and his issue of butter and cholesterol. Robert's judgment if he believes that "eating butter leads to high cholesterol, which might lead to cardiac infarction", refers to the question how certain this knowledge claim is. This question is quite hard for him to answer, because he does not have much knowledge about the topic. That means that he is not able to estimate how trustworthy the assertion is, because he does not know much about the concept 'cholesterol'. Furthermore, he needs to have some knowledge about the conditions for subsuming a casual relationship, in this case between cholesterol and cardiac infarction.

It is obvious that some amount of *topic-related knowledge* is necessary in order to judge about the viability or "truth" of knowledge claims. This includes for example knowledge about the research methods used to justify knowledge claims insofar as the ways of producing, justifying and distributing knowledge are specific for a certain discipline. For example, people with poor knowledge in physics will not have ample knowledge about the methods used within the field. They may mainly think of methods to measure physical quantities like temperature or mass, which are commonly assumed to be quite reliable and valid. Therefore they may state that knowledge in physics is certain and stable. People with low knowledge about research methods in physics might probably disregard that within the discipline there are also methods which are still developing, more insecure or at least more complex, for example polarization-correlation measurements or transmission electrons microscopy. In contrast,

[2] Of course, the question what counts as truth or which conditions have to be fulfilled until one can consider an assertion as certain is very controversial in both the philosophy of science and in everyday thinking. The assumed central role of the certainty aspect is congruent with the assumption of multidimensionality of epistemological beliefs (e.g., Pintrich, 2002; Rozendaal et al., 2001). We just argue that the different dimensions all contribute to the core question of certainty (or validity, viability, truthfulness) of knowledge claims.

people with more knowledge about research methods in physics may consider this variety of methods and therefore pass more differentiated epistemological judgments.

Furthermore, some *ontological assumptions* about the topic respectively the wider discipline the topic belongs to are necessary for the judgment about knowledge claims. Ontological assumptions are categorical assumptions about the "reality" based on a certain perspective. Coherent bodies of knowledge (e.g., academic disciplines, but also lay theories, e.g., folk psychology or folk biology) have such underlying ontologies. For example: While "goals" and "intentions" could be conceived as legitimate explanations for the behavior of humans it would be a categorical error to refer to "intentions" as explanations for the behavior of physical entities such as stones, light waves and molecules (Keil, 2006). Also the assignment of topics and of questions to certain disciplines is based on ontological assumptions.

In our example, Robert conceives the topic "cholesterol and the cardiovascular system" as a medical topic. Anne instead learned about it in a biology context. In spite of the many relationships between biology and medicine even these disciplines differ remarkably with regard to their ways of establishing 'truth'.

Only when someone knows the questions a discipline deals with she is able to know the features which have to be taken into account for the assessment of certainty. Thus, ontological assumptions are closely related to topic-related knowledge.

Ontological knowledge as well as topic-related knowledge impact on epistemological judgments. An example: It has been reported in several studies that knowledge in science, mathematics or physics is conceived to be more stable and certain than knowledge in history or psychology (Buehl et al., 2002; Hofer, 2000). Such judgments rely not only on epistemological features of the disciplines. The very fact that "truth" in physics is different from "truth" in history does not only reflect differences between the ways how knowledge is dealt with in these two disciplines (an epistemological issue), but also the ontological differences between the world of history and the world of physics.

Even epistemological judgments within a discipline are influenced by ontological assumptions, not only by epistemological beliefs. Consider for example, well-established theories like Newton's laws applied to the world around us (falling stones, moving cars). In case of Newton's laws we might assume that these laws are able to model physical reality. This assumption is based on ontological assumptions about the world we experience in our daily life. When we judge the certainty of statements about this theory we do not only refer to our epistemological beliefs, but also to our assumptions about the ontology of mechanics. Instead, we might have a much more skeptical view when we think about statements on the unified theory of physics. Here it is very difficult to imagine the "world" this theory refers to and therefore epistemological judgments about the certainty of such theories might be much more skeptical with regard to the absoluteness of such knowledge claims.

The impact of topic-related knowledge and ontological assumptions raises also a methodical challenge. Evidence for the existence of discipline-specific or even topic-specific epistemological beliefs is deduced from the existing variance between the judgments for different disciplines (Buehl et al., 2002) or different specific theories (Trautwein & Lüdtke, in press, b). However, such results are to some degree confunded: When someone has to judge a statement like "All experts in this field (physics, history) understand the field in the same way," she may not only judge the stability or dynamics of knowledge in the field, but may also refer to the ontological "quality" of the world of history or the world of physics. When a subject within the Trautwein and Lüdtke study has been asked to judge the viability of the Big Bang theory (a physics theory about the genesis of our solar system), her answer will not only be based on her epistemological beliefs but also on her topic-related knowledge and ontological assumptions about our solar system.

Coming back to *the heterogeneous research results* summarized in section 20.2, a nonlinear relationship between sophisticatedness and knowledge seems not that striking. It is reasonable that individuals without prior knowledge on a topic refer to everyday understanding when they have to deal with a specific knowledge claim. For example, their everyday understanding of knowledge in psychology or biology may include that knowledge in these fields is not very certain. Therefore such individuals seem to be "sophisticated," at least when responding to instruments which do not account for the impact of topic-related knowledge and ontological assumptions. When such individuals study a certain discipline, their growing knowledge base may lead to the assumption that knowledge in the discipline is stable, secure and absolute, as the learner gets to know a world of facts and well-established theories. Therefore it is much less surprising that individuals who learn about a topic seem to take up a less sophisticated epistemological standpoint compared to the standpoint they had before. Only when they have acquired further knowledge they might – again – realize that the viability of knowledge claims still depends on methods and viewpoints, even if there are good reasons to prefer one viewpoint instead of another. With growing knowledge for example about the history of research, concurring theories, or research methods within a specific discipline, one will probably realize that knowledge in the discipline is dynamic and changing. It has been underlined above that this also depends on ontological features of the "world" the respective discipline refers to (world of physics, history, or psychology).

It has to be emphasized that it is necessary to clarify the concept of "sophisticatedness" in order to test the hypothesis of such a nonlinear relationship (from "sophisticated" via "naive" to again more "sophisticated" views) empirically. We will refer to the key aspects of sophistication in the next paragraph.

20.4 Sophistication = Flexible Adaptation of Epistemological Judgments to Contexts

Imagine Anne having to decide if she believes that LDL cholesterol raises the risk of cardiac infarction, as she read in her textbook. She will have quite a lot topic-related arguments and reasons (like data, theories, own or others' experience) in mind. In the normal case of academic learning and research, it might be possible to evaluate the certainty of concurring knowledge claims by regarding mainly topic-related knowledge and ontological knowledge. That means that she regards current biological and medical concepts about *cholesterol, the vascular system, or risk as facts or real entities. This way to handle complex issues is necessary for learning as well as for the daily work in the lab. In Anne's case, the approaches to knowledge are different in the different courses. In the biology course, "cholesterol," "cardiovascular system" or "risks" are treated as facts about which one can think and communicate as real entities. In the course on medical history, for a sophisticated understanding the same concepts have to be regarded as negotiated constructs.*

Of course, Anne's evaluations and the underlying ontological arguments have to meet epistemological requirements, but in everyday work it is not necessary to reflect about them. Studies on the sociology of knowledge production in the setting of scientific labs (Fleck, 1977; Latour & Woolgard, 1979) have shown that researchers commonly treat the issues they investigate in an "epistemologically naive" way. If Anne would be asked about the viability of knowledge claims within such a context she might respond in a way which might be classified as "naïve" within traditional questionnaires. But is that appropriate? We do not think so. Instead, we would argue that Anne would only be naïve if she insisted that "cholesterol", "risk", and the "cardiovascular system" should be conceived as real entities and not as theoretical notions under all circumstances.

Anne's beliefs would be sophisticated when she would be able to understand and apply different beliefs about knowledge within the biology course and the history course. For example, she should be able to do her work in the lab based on the fiction of stable and certain entities within the cardiovascular system. Otherwise she would not be able to learn from the textbook or to conduct studies. However, she should also be able to acknowledge that these concepts are just construed and are a mirror of the current scientific stance in biology. It would also be very sophisticated if she would be aware that the same topic might be conceived theoretically different (at least to a certain degree) in biology and in medicine. To sum up, Anne would be sophisticated if she understands the differences between the contexts and accordingly adjusts her judgments of knowledge claims.

Such flexibility is also necessary for scientific progress. It is important not to lose sight of the uncertainty and variability of the concepts when "puzzles" occur within the daily work of a researcher. This is especially necessary to avoid scientific stagnation and allow for a change of paradigms (Thomas Kuhn, 1970). To sum up: *We suggest conceiving "sophisticated epistemological beliefs" as those beliefs which allow for context-sensitive judgments about knowledge claims*. That notion of sophisticatedness could enlighten the above-described heterogeneity of research results about the relationship between knowledge and epistemological beliefs.

Our suggestion is of course inspired by recent discussions on methodical and conceptual issues of research on epistemological beliefs. Hofer (2006, p. 90) stated that nowadays "few researchers would likely claim that context does not play a role in both shaping and eliciting students" epistemic beliefs, and we have increasing evidence to support this." Problems to replicate findings and limitations in the attempt to generalize results over different contexts resulted in the emphasis of the role of the context in measuring epistemological beliefs (Bromme, 2005; Chandler et al., 2002; Elby et al., 2003; Elby & Hammer, 2001; Hammer & Elby, 2002; Pintrich, 2002). The important role the sociocultural context is also emphasized by Buehl and Alexander (2006), Baxter Magolda (2004), Belenky et al. (1986), Bendixen and Rule (2004) or Muis et al. (2006). Many researchers convincingly argue that we as researchers have to take into account the context-dependency of epistemological beliefs, so to say, that we have to take into account the intraindividual and the intercontextual variance of epistemological beliefs. We agree with this view, but would go one step further (just as Elby and Hammer have done, e.g., 2001) and would like to suggest that the *subjects' ability to produce such intercontextual variance* should be conceived as "sophisticatedness."

20.5 The Generative Nature of Epistemological Beliefs

So far, we have claimed that epistemological judgments rely on different sources, like (discipline specific) epistemological beliefs, ontological knowledge, and topic-related knowledge. Furthermore, we have pointed out that sophisticatedness means flexibility with regard to a specific discipline and a specific context. What is unclear till now is how the cognitive system can ensure such flexibility.

Is it necessary to have a vast amount of topic-related and ontological knowledge for all possible combinations of disciplines and contexts? How could the different sources (epistemological beliefs, ontological knowledge, and topic-related knowledge) be used within a certain context? How could subjects provide flexible judgments about the nature of knowledge between different contexts, but nevertheless be able to judge similar contexts in similar ways? These are of course empirical questions which still have to be solved. Nevertheless, we will point to some psychological approaches on human knowledge representation which might offer first theoretical ideas for the assumed flexibility.

In cognitive psychology, several approaches have been developed in order to explain the flexibility of knowledge. To refer to three prominent examples:

- The ideas of schemata (e.g., Bartlett, 1932; Schank, 1972) or scripts (Schank & Abelson, 1977) are commonly used to describe complex knowledge organizations. Nevertheless, these ideas had to be modified to account to a higher flexibility. For example, Rumelhart et al. (1986) explained schemata with a connectionist idea: They emerge in the moment when they are activated from patterns of interconnected elements. Thus schemata are not explicitly stored in memory but are constructed by processes of activation and inhibition of smaller units. Schank (1982) introduced the idea of MOP's (Memory Organization Packets) – hierarchically ordered memory packets of different levels of abstraction that interact with each other and can be combined to form scripts. The advantage is that each MOP (e.g., the MOP how to pay) can be activated in different contexts (e.g., paying in a restaurant, paying at the coiffeur). The main idea is that stable and therefore inflexible general units like whole scripts are reduced to ensembles of smaller units, allowing higher flexibility in different contexts.
- Barsalou (e.g., 1987) challenged the view that representations of concepts are relatively static and gave empirical and theoretical evidence that concepts (and also the structure of categories and even some categories as such) are unstable and

change as a function of the context. For example, "duck" would be associated with other characteristics during a walk around a pound than during a visit of a Chinese restaurant. Nevertheless, whenever a concept is activated, there is also some more general information, that is automatically activated as well, for example, that a "duck" is an animal. Thus, the actual meaning of a concept can be seen as a mixture of context-independent and of context-related characteristics. Barsalou argues that this allows for great flexibility of the cognitive system.

– Kintsch (1998) included such ideas as presented by Barsalou (1987) into his CI Model (construction-integration model) of text comprehension. He argues that knowledge is represented in the form of a network of propositions. This network with its existing propositions and the connections between the propositions defines the whole information that can be activated at all. But, only parts of this network are activated within a concrete context – for example, while reading a specific text. This is done in a process of "constraint satisfaction." This means that a context (= the text) inflicts semantic constraints. These allow for inhibition of propositions that are incorrect in the context and activation of those propositions that represent an adequate meaning. Important for flexible and adequate activation of knowledge is therefore that (a) a learner has a detailed and comprehensive knowledge structure and that (b) she is able to interpret the demands/constraints of a given context.

All examples represent modifications in theoretical models that were introduced to take into account the high flexibility and context-dependency of our cognitive system. It is therefore reasonable to assume that epistemological judgments might be influenced by comparable processes of context-dependent activation.

Buehl and Alexander (2006) define epistemological beliefs as complex, multidimensional, multilayered, and interactive. They argue that many knowledge characteristics and characteristics of beliefs about knowledge should be seen as comparable because of influences between knowledge acquisition and the forming of epistemological beliefs. Thus, if knowledge can be defined as complex, multidimensional, multilayered, and interactive, then there is no reason to assume that a construct like "epistemological beliefs" should be seen as more simple. We agree with this view and add that it should also be reasonable to use existing models of the structure of the cognitive system, like those presented above, as fruitful heuristics to think about the structure of epistemological beliefs as well.

This would mean that epistemological beliefs could be flexible in contexts because they are of a generative nature. This aspect is also taken into account by Hammer and Elby (2002). They argue that most researchers define epistemological beliefs as belief systems, theories or traits. In these views epistemological beliefs can be seen as analogue to concepts or "unitary elements of the cognitive structure." Hammer and Elby argue that such unitary elements would result in stable epistemologies that could not account for the context-dependency found in empirical studies. Their alternative explanation is to define epistemological resources. In reference to the works of Minsky (1986) and diSessa (1993) they assume that individuals hold small elements (p-primes in sense of diSessa) that can be activated and combined in specific contexts to make epistemological judgments. Hammer and Elby define these elements as epistemological resources and suggest a framework of four categories of epistemological resources. To give an example, their first resource is the metaphorical notion of "knowledge as stuff." This is inspired by the theory about metaphors by Lakoff (1990) and Lakoff and Johnson (1980). They assume that metaphors relate our conceptual knowledge to basic sensual experiences we make within our environment. In this sense metaphors are more than communicative resources but basic elements that structure our perception and thinking.

The conception of Hammer and Elby is in line with the above-sketched notion of the generative nature of epistemological beliefs, which leads to epistemological judgments. Nevertheless, we prefer to explain the generative nature in sense of Kintsch (1998). Epistemological beliefs, ontological knowledge, and topic-related knowledge are the sources that can be activated within different contexts. They can complement or compensate each other to attain an epistemological judgment. When someone has only poor topic-related knowledge, ontological knowledge, and discipline-specific epistemological beliefs with regard to a context, then her epistemological judgments can only be stereotypical and inflexible. In analogy to the CI-Model of Kintsch sophisticatedness relies on the comprehensiveness of the sources and the ability to take the demands of a context into account. To conclude, different sources contribute to the generation of epistemological judgments.

20.6 Most Epistemological Judgments Make Use of a "Division of Cognitive Labor"

So far we have suggested conceiving "sophisticatedness" as the ability to take into account the differences between contexts. We have already exemplified this view with regard to Anne.

> *Anne would be classified as holding sophisticated beliefs if she is able to think about a concept like "cardiovascular system" within one context as a viable fact about a stable reality "out there" and concurrently as a theoretical concept embedded in a certain theoretical paradigm within another context.*

We have emphasized that such epistemological judgments do require ontological knowledge, topic-related knowledge and epistemological beliefs as sources. Does that imply that all sources have to be fully elaborated and almost all-embracing to take up a sophisticated standpoint?

> *What about Robert searching for information about the cardiovascular system on the Internet? Robert has no university degree in biology. Is it possible at all to make a sophisticated epistemological judgment with regard to a topic without having elaborated knowledge about that topic? In our view, it is possible, although Robert has to solve his problem in a (partially) different way than Anne. Within his setting of informal learning he mainly has to judge about the trustworthiness of the different sources which are accessible for him (external representations, experts). Of course, he would also need some topic-related as well as ontological knowledge and a basic understanding of science based explanations. But again such basic understanding is mainly necessary for his judgments about the sources of competing knowledge claims. For example, he has to figure out who is "responsible" (the biologist, the medical expert, the nutrition expert) for the topic he is interested in.*

In many cases "sophisticated" epistemological judgments require knowledge about the division of cognitive labor: Who is "responsible" for which topic and how to decide about the credibility and relevance of different and sometimes competing sources of knowledge claims? Predominantly, our knowledge acquired during life does not derive from personal, direct experience, but from other people's experiences, considerations or analyses, at first from parents and peers, later from teachers, and it is mostly transferred through cultural artefacts like books, TV or the Internet (Bergstrom et al., 2006). There is evidence from developmental psychology that even young children are aware that people have different areas of expertise, and that they know how knowledge is clustered in the minds of others (Lutz & Keil, 2002). One could argue that most judgments about knowledge claims cannot be made referring to own personal experience, but are based on information from other sources. The question if one accepts a knowledge claim or not shifts toward the question of the credibility of the source of knowledge, which is in the end the expert who is responsible for that claim. In a study about laypersons seeking for medical advice from different sources (Internet, journals), we have found evidence for coherent criteria laypersons use to assess the trustworthiness of different sources (Wittwer et al., 2004).

Most current conceptualizations of epistemological beliefs do not account for the division of cognitive labor. However, Rozendaal et al. (2001) emphasize that knowledge construction does not take place in a vacuum, but in a social process of discussion. Consequently, they state that "beliefs about the social character of knowledge construction belong to the core of epistemological beliefs because they hold immediate consequences for the need to validate that knowledge" (Rozendaal et al., 2001, p. 5).

Most dimensions mentioned in the literature that make up personal epistemology – like simplicity, certainty, and justification of knowledge – imply a view of the subject as an independent and "active" information seeker, maybe due to the normative ideal of an autonomous learner who makes up her mind independently from authorities (Perry, 1970). Only the dimension "source" pays attention to the division of cognitive labor.

The division of cognitive labor is one of the most salient characteristics of a modern knowledge-based society. Even researchers, who are "professionals" for the assessment of knowledge claims, have to rely on other researchers' work, as they refer to former data and theories. The direct testing of evidence by one's own hand is a rare exception. Predominantly, gaining knowledge means attaining shared knowledge and therefore an evaluation of the trustworthiness of others.

20.7 Summary and Implications for Research

In this chapter, we have focused on the important but sometimes underestimated role of knowledge for making epistemological judgments. Empirical evidence indicates that epistemological beliefs and knowledge are highly related to each other, but also that this relationship is more complex than often assumed. There are a lot of empirical studies pointing out that more advanced epistemological beliefs are related to better learning, but there are also several studies indicating a nonlinear relationship. To shed some light on these conflicting results, we distinguish between topic-related knowledge and ontological knowledge. We claim that epistemological judgments onto a specific topic rely on different sources, like (discipline specific) epistemological beliefs, ontological knowledge, and topic-related knowledge. Furthermore, we suggest conceiving sophisticatedness as flexibility of epistemological judgments with regard to differences between contexts. To ensure such flexibility, one does not need to have a vast number of constellations for all possible combinations of disciplines and contexts in mind. Based on existing theories about the flexibility of human conceptual knowledge, it can be assumed that different sources contribute to the generation of an epistemological judgment. The generation of epistemological judgments relies on the comprehensiveness of specific epistemological beliefs, ontological knowledge and topic-related knowledge as well as on the ability to take the demands of a context into account. Nevertheless, even when the different sources are not fully elaborated and all-embracing, someone can take up a sophisticated standpoint. People are still able to solve epistemological judgments sophisticatedly, as the question of certainty of knowledge coincides with the question of trustworthiness of experts or more generally the question of credibility of the source of knowledge. In many cases, epistemological judgments include assumptions about the division of cognitive labor. This has not yet been regarded in research on epistemological beliefs.

The arguments exposed in this chapter have been inspired by the heterogeneity of findings about knowledge and epistemological beliefs reviewed in section 20.3 of this chapter. They are also in line with several arguments put forward by other researchers in recent contributions on conceptual problems of research on epistemological beliefs. Nevertheless, our arguments should be regarded as a theoretical outline which has to be tested empirically.

Finally, we will mention a few methodical consequences of our assumptions. First of all, we would like to emphasize the need for a careful interpretation of the data obtained with many questionnaires used in the field. We assume that the answers to current questionnaires mirror not solely learners' epistemological beliefs but unavoidably also to some degree topic-related knowledge and ontological assumptions. Therefore topic-related knowledge should additionally be taken into account when measuring epistemological beliefs. Furthermore, individuals' subjective ontological assumptions with regard to a specific discipline should also be considered. Besides, the discipline, a topic is subjectively assigned to, has to be checked empirically. Researchers often neglect the fact that a topic might be assigned to another discipline than they have had in mind.

Taking the different sources contributing to epistemological judgments into account might lessen some of the current methodological problems. In our view, measurement problems may not only be based on the quality of the common questionnaires, as it is often assumed. Instead, they may also derive from the conceptual complexity of epistemological judgments. By taking into account the different contributing sources, one may be able to lower error variance. As a result, it would be necessary to develop and combine instruments measuring epistemological beliefs, topic-related knowledge and ontological knowledge to gain a clearer picture of the impact of these different sources on epistemological judgments in a concrete context.

Another conclusion of our outline concerns the dimension "source of knowledge." It will be necessary to explore into individuals' understanding of the division of cognitive labor. Relying on others does not necessarily mean to be less sophisticated.

All in all, we would like to emphasize that up to now we can only offer heuristic and maybe preliminary alternatives to the sometimes simplified relationship between knowledge and epistemological beliefs. Future research should therefore among others focus on the distinction between ontological assumptions and epistemological beliefs as well as on the interplay between the different sources feeding epistemological judgments.

References

Barsalou, L. W. (1987). The instability of graded structure: Implications for the nature of concepts. In U. Neisser (Ed.), *Concepts and conceptual development: Ecological and intellectual factors in categorization* (pp. 101–140). Cambridge: Cambridge University Press.

Bartlett, F. C. (1932). *Remembering*. Cambridge: Cambridge University Press.

Bartholomé, T., Stahl, E., Pieschl, S., & Bromme, R. (2006). What matters in help-seeking? A study of help effectiveness and learner-related factors. *Computers in Human Behavior*, 22, 113–129.

Baxter Magolda, M. B. (2004). A constructivist conceptualization of epistemological reflection. *Educational Psychologist*, 39, 31–42.

Belenky, M., Clinchy, B., Goldberger, N., & Tarule, J. (1986). *Women's ways of knowing: The development of self, voice, and mind*. New York: Basic Books.

Bendixen, L. D., & Rule, D. C. (2004). An integrative approach to personal epistemology: A guiding model. *Educational Psychologist*, 39, 69–80.

Bergstrom, B., Moehlmann, B., & Boyer, P. (2006). Extending the testimony problem: Evaluating the truth, scope, and source of cultural information. *Child Development*, 77, 531–538.

Bromme, R. (2005). Thinking and knowing about knowledge: A plea for and critical remarks on psychological research programs on epistemological beliefs. In M. Hoffmann, J. Lenhard, & F. Seeger, (Eds.), *Activity and sign – grounding mathematics education* (pp. 191–201). New York: Springer.

Bromme, R., & Stahl, E. (2003). The impact of epistemological beliefs on e-learning: The case of help-seeking. In F. W. Hesse & Y. Tamura (Eds.), *The joint workshop of cognition and learning through media-communication for advanced e-learning* (pp. 29–35). Berlin.

Buehl, M. M., & Alexander, P. A. (2006). Examining the dual nature of epistemological beliefs. *International Journal of Educational Research*, 45, 28–42.

Buehl, M. M., & Alexander, P. A. (2005). Motivation and performance differences in students' domain-specific epistemological belief profiles. *American Educational Research Journal*, 42, 697–726.

Buehl, M. M., Alexander, P. A., & Murphy, P. K. (2002). Beliefs about schooled knowledge: Domain general or domain specific? *Contemporary Educational Psychology*, 27, 415–449.

Chandler, M. J., Hallett, D., & Sokol, B. W. (2002). Competing claims about competing knowledge claims. In B. K. Hofer & P. R. Pintrich (Eds.), *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 145–168). Mahwah, NJ: Erlbaum.

De Corte, E., Op't Eynde, P., & Verschaffel, L. (2002). "Knowing what to believe": The relevance of students' mathematical beliefs for mathematics education. In B. K. Hofer & P. R. Pintrich (Eds.), *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 297–320). Mahwah, NJ: Lawrence Erlbaum.

diSessa, A. (1993). Towards an epistemology of physics. *Cognition and Instruction*, 10, 105–225.

Elby, A., Frederiksen, J., Schwarz, C., & White, B. (2003). *Epistemological beliefs assessment for physical science (EBAPS)*. Retrieved 05/20/2003: http//www2.physics.umd.edu/~elby/EBAPS/home.htm.

Elby, A., & Hammer, D. (2001). On the substance of sophisticated epistemology. *Science Education*, 85, 554–567.

Fleck, L. (1977). *Genesis and development of a scientific fact*. Chicago, IL: The University of Chicago Press.

Hammer, D., & Elby, A. (2002). On the form of a personal epistemology. In B. K. Hofer & P. R. Pintrich (Eds.), *Personal epistemology: The psychology of beliefs about knowledge and knowing*. Mahwah, NJ: Erlbaum.

Hartley, K., & Bendixen, L. D. (2003). The use of comprehension aids in a hypermedia environment: Investigating the impact of metacognitive awareness and epistemological beliefs. *Journal of Educational Multimedia and Hypermedia*, 12, 275–289.

Hofer, B. K. (2000). On dimensionality and disciplinary differences in personal epistemology. *Contemporary Educational Psychology*, 25, 378–405.

Hofer, B. K. (2004). Epistemological understanding as a metacognitive process: Thinking aloud during online searching. *Educational Psychologist*, 39, 43–55.

Hofer, B. K. (2006). Domain specificity of personal epistemology: Resolved questions, persistent issues, new models. *International Journal of Educational Research*, 45, 85–95.

Jacobson, M. J., & Spiro, R. J. (1995). Hypertext learning environments, cognitive flexibility, and the transfer of complex knowledge: An empirical investigation. *Journal of Educational Computing Research*, 12, 301–333.

Jacobson, M. J., Maouri, C., Mishra, P., & Kolar, C. (1996). Learning with hypertext learning environments: Theory, design, and research. *Journal of Educational Multimedia and Hypermedia*, 5, 239–281.

Kardash, C. M., & Scholes, R. J. (1996). Effects of preexisting beliefs, epistemological beliefs, and need for cognition on interpretation of controversial issues. *Journal of Educational Psychology*, 88, 260–271.

Kardash, C. M., & Howell, K. L. (2000). Effects of epistemological beliefs and topic-specific beliefs on undergraduates' cognitive and strategic processing of dual-positional text. *Journal of Educational Psychology*, 92, 524–535.

Keil, F. C. (2006). Explanation and understanding. *Annual Review of Psychology*, 57, 227–254.

Kienhues, D., Bromme, R., & Stahl, E. (in press). Changing epistemological beliefs: The unexpected impact of a short term intervention. *British Journal of Educational Psychology*.

King, P. M., & Kitchener, K. S. (2002). The reflective judgment model: Twenty years of research on epistemic cognition. In B. K. Hofer & P. R. Pintrich (Eds.), *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 37–61). Mahwah, NJ: Erlbaum.

Kintsch, W. (1998). *Comprehension: A paradigma for cognition*. New York: Cambridge University Press.

Köller, O., Baumert, J., & Neubrand, J. (2000). Epistemologische Überzeugungen und Fachverständnis im Mathematik– und Physikunterricht [Epistemological beliefs and understanding of science in mathematics and physics lessons]. In J. Baumert, W. Bos, & R. Lehmann (Eds.), *TIMSS/III: Dritte Iinternationale Mathematik – und Naturwissenschaftsstudie – Mathematische und naturwissenschaftliche Bildung am Ende der Schullaufbahn* (pp. 229–269). Opladen: Leske + Budrich.

Kuhn, D., Cheney, R., & Weinstock, M. (2000). The development of epistemological understanding. *Cognitive Development*, 15, 309–328.

Kuhn, T. S. (1970). *The structure of scientific revolutions*. Chicago, IL: University of Chicago Press.

Labudde, P. (1998). *Konstruktivismus im Physikunterricht der Sekundarstufe SII [Constructivism in physic classes of Sekundarstufe II (German school system)]*. Bern: Universität Bern.

Lakoff, G. (1990). *Women, fire, and dangerous things*. Chicago, IL: University of Chicago Press.

Lakoff, G., & Johnson, M. (1980). *Metaphors we live by*. Chicago, IL: University of Chicago Press.

Latour B., & Woolgard, S. (1979). *Laboratory life: The construction of scientific facts*. Princeton, NJ: Princeton University Press.

Limon, M. (2005). *Students and teachers' epistemologies of history*. Paper presented at the 11th European Conference for Research on Learning and Instruction (EARLI), Nikosia, Cyprus.

Limon, M. (2006). The domain generality-specificity of epistemological beliefs: A theoretical, a methodological problem or both? *International Journal of Educational Research*, 45, 7–27.

Lutz, D. J., & Keil, F. C. (2002). Early understanding of the division of cognitive labor. *Child Development*, 73, 1073–1084.

Maggioni, L., Alexander, P., & VanSledright, B. (2004). At a crossroads: The development of epistemological beliefs in historical thinking. *European Journal of School Psychology*, 2, 169–200.

Mason, L., & Boscolo, P. (2004). Role of epistemological understanding and interest in interpreting a controversy an in topic-specific belief change. *Contemporary Educational Psychology*, 29, 103–128.

Minsky, M. L. (1986). *Society of mind*. New York: Simon & Schuster.

Muis, K. R. (2004). Personal epistemology and mathematics: A critical review and synthesis of research. *Review of Educational Research*, 74, 317–377.

Muis, K. R., Bendixen, L. D., & Haerle, F. C. (2006). Domain-generality and domain-specificity in personal epistemology research: Philosophical and empirical reflections in the development of a theoretical framework. *Educational Psychology Review*, 18, 3–54.

Op't Eynde, P., de Corte, E., & Verschaffel, L. (2006). Epistemic dimensions of students' mathematics-related belief systems. *International Journal of Educational Research*, 45, 57–70.

Perry, W. G. (1970). *Forms of intellectual and ethical development in the college years: A scheme*. San Francisco, CA: Jossey-Bass.

Pintrich, P. R. (2002). Future challenges and directions for theory and research on personal epistemology. In B. K. Hofer & P. R. Pintrich (Eds.), *Personal epistemology: The psychology of beliefs about knowledge and knowing*. Mahwah, NJ: Erlbaum.

Qian, G., & Alvermann, D. E. (2000). Relationship between epistemological beliefs and conceptual change learning. *Reading & Writing Quarterly*, 16, 59–74.

Redish, E. F., Saul, J. M., & Steinberg, R. N. (1998). Student expectations in introductory physics. *American Journal of Physics*, 66, 212–224.

Richter, T. (2003). *Epistemologische Einschätzungen beim Textverstehen* [Epistemological judgements during text comprehension]. Lengerich: Pabst.

Rozendaal, J. S., de Brabander, C. J., & Minnaert, A. (2001). *Boundaries and dimensionality of epistemological beliefs*. Paper presented at the 9th European Conference for Research on Learning and Instruction, Fribourg, Switzerland.

Rumelhart, D. E., Smolensky, P., McClelland, J. L., & Hinton, G. E. (1986). Schemata and sequential thought processes in PDP models. In J. L. McClelland, D. E. Rumelhart, & the PDP Reserach Group (Eds.), *Parallel distribution processing,* Volume 2: *Psychological & biological models*. Cambridge, MA: MIT Press.

Ryan, M. P. (1984). Conceptions of prose coherence: Individual differences in epistemological standards. *Journal of Educational Psychology*, 76, 1226–1238.

Schank, R. C. (1982). *Dynamic memory: A theory of reminding and learning in computers and people*. Cambridge: Cambridge University Press.

Schank, R. C. (1972). *Dynamic memory*. Cambridge: Cambridge University Press.

Schank, R. C., & Abelson, R. P. (1977). *Scripts, plans, goals and understanding*. Hillsdale, NJ: Erlbaum.

Scheiter, K., Gerjets, P., Vollmann, B., & Catrambone, R. (2007). *The impact of learner characteristics on processing strategies, cognitive load, and learning outcomes in hypermedia learning*. Unpublished manuscript.

Schommer, M. (1990). Effects of beliefs about the nature of knowledge on comprehension. *Journal of Educational Psychology*, 82, 498–504.

Schraw, G., Dunkle, M. E., & Bendixen, L. D. (1995). Cognitive processes in well-defined and ill-defined problem solving. *Applied Cognitive Psychology*, 9, 523–538.

Sinatra, G. M. & Pintrich, P. R. (2003). *Intentional conceptual change*. Mahwah, NJ: Lawrence Erlbaum.

Stahl, E., & Bromme, R. (in press). The CAEB. An instrument for measuring connotative aspects of epistemological beliefs. *Learning and Instruction*.

Stathopoulou, C., & Vosniadou, S. (in press). Exploring the relationship between physics-related epistemological beliefs and physics understanding. *Contemporary Educational Psychology*.

Trautwein, U., & Lüdtke, O. (in press, a). Epistemological beliefs, school achievement, and college major: A large-scale longitudinal study on the impact of certainty beliefs. *Contemporary Educational Psychology*.

Trautwein, U., & Lüdtke, O. (in press, b). Predicting global and topic-specific certainty beliefs: Domain-specificity and the role of the academic environment. *British Journal of Educational Psychology*.

Tsai, C. -C., & Chuang, S. -C. (2005). The correlation between epistemological beliefs and preferences toward internet-based learning environments. *British Journal of Educational Technology*, 36, 97–100.

Windschitl, M., & Andre, T. (1998). Using computer simulations to enhance conceptual change: The roles of constructivist instruction and student epistemological beliefs. *Journal of Research in Science Teaching*, 35, 145–160.

Wittwer, J., Bromme, R., & Jucks, R. (2004). Kann man dem Internet trauen, wenn es um die Gesundheit geht? Die Glaubwürdigkeitsbeurteilung medizinischer Fachinformationen im Internet durch Laien [Is the Internet trustworthy when it comes to health matters? Layperson's assessing the credibility of medical information from the Internet.] *Zeitschrift für Medienpsychologie*, 2, 48–56.

Part V
Conclusion

Chapter 21
Challenges and Future Directions for Personal Epistemology Research in Diverse Cultures

Benjamin Wong[1], **Myint Swe Khine**[2], **and Chai Ching Sing**[3]

Abstract Beliefs about nature of knowledge and learning, or epistemological beliefs have been an interest of educational researchers and psychologists for the past several years. New perspectives on theoretical, conceptual, and methodological approaches as well as empirical studies on epistemological beliefs are emerging in the literature as a well-defined field of study. Studies show that personal epistemology has influence on comprehension, study strategies, learning process and academic performance. Research in this area has undergone considerable growth in the past decades and has now reached a stage of notable diversity and internationalization. The chapters in this book reported by the educators and researchers from around the world share their experiences in providing theoretical framework and model building and contemporary research on the role of epistemological beliefs in learning. In this concluding chapter the major contributions and salient points by the contributors are summarized and reviewed with a view to clarifying the problems and prospects of further research on epistemological beliefs.

21.1 Introduction

General considerations regarding the current state and future direction of epistemological studies have been extensively treated by most authors in this volume. Hofer, for instance, has critically surveyed several substantive issues dealing with students' conceptions of knowledge and knowing, and has listed a series of searching questions that ought to be addressed in subsequent projects on personal epistemology across cultures. Buehl, on the other hand, has undertaken a rigorous review and critique of existing works on the dimensionality of epistemic beliefs, bringing to light some of their methodological shortcomings, and concluding with several recommendations for future research. Others have highlighted potential areas of

---

[1] *Nanyang Technological University, Singapore*

[2] *Murdoch University, Australia*

[3] *Nanyang Technological University, Singapore*

M. S. Khine (ed.), *Knowing, Knowledge and Beliefs: Epistemological Studies across Diverse Cultures.*

exploration arising from their current research findings. Accordingly there is no need to restate or to summarize the recommendations for research in the field, except where they bear on the concerns of this chapter. The aim of this chapter is to share our reflections on the challenges to future research on personal epistemology on the basis of the studies and findings presented in this volume.

21.2 The Teacher–Student Relationship

We begin by asking the basic question of the purpose of study of personal epistemology. According to Palmer and Marra, “researchers and educators would not be very interested in epistemology unless it also has practical implications for learners and instructors.” Or as Buehl puts it: “Understanding how knowledge beliefs relate to other factors within the learning environment may help to account for students’ successes and difficulties in the classroom and offer an avenue for improving education.” One purpose of epistemological studies is the improvement of education and the learning of students, including those of adults beyond the formal school system.

Epistemological studies assume that there is some relation, direct or otherwise, between beliefs about knowledge, learning strategies, and educational performance. Some of the studies reported in this volume show that teachers contribute to or influence students’ epistemological beliefs, and that the relation between teacher and student should therefore merit greater attention. As a result of their research on domain specific personal epistemologies, Palmer and Marra characterize the relationship of classroom practices to personal epistemology as one that is “particularly potent.” In keeping with this perspective, most of the studies in this volume point to the role that teachers or instructors play in shaping the beliefs of students. Some appropriate consideration will be to focus on the dynamics of the teacher–student relationship. As Haerle and Bendixen point out, “very little research in personal epistemology is applied and/or more process oriented.” So much more needs to be done to understand the transformation or development of epistemological beliefs as a result of the teacher-student relationship in the context of classroom practices.

The role of the teacher in determining instruction and classroom practices contribute to students’ belief about the nature of knowledge in particular disciplines. Several studies in this volume seem to provide evidence that teachers who have more sophisticated epistemological beliefs and/or who take a more constructivist pedagogy are able to advance the epistemological beliefs of students. On the other hand, Bromme, Kienhues, and Stahl, report that their studies and others have found that “gaining more knowledge about a specific topic can provoke less advanced epistemological beliefs.” Teachers therefore seem to influence students in a variety of ways in the context of classroom practices.

Even though teachers may advance, retard, or even impede the epistemological development of students, this still leaves open what the impact these changes have on the academic performance of students. It is generally assumed that better learning strategies that reflect more "sophisticated" epistemological beliefs would in turn contribute to better academic performance. As Hofer notes in her chapter, "advance epistemological understanding was a significant predictor of the three components of argumentation skills; arguments, counter-argument, and rebuttals providing justification." Argumentation skills presumably constitute some crucial aspect of academic performance. But at the same time Shraw and Olafson claim that there is "low predictive validity between epistemological factors used in ongoing research and various outcome variables such as academic achievement." According to their research, correlations between epistemological beliefs and academic performance "typically account for 3% to 8% of sample variance in the outcome measure." Moreover, several studies suggest that less sophisticated epistemological beliefs may be correlated to high academic achievement.

Perhaps the problem here has to do with the understanding of what academic achievement means. Those students who display more sophisticated epistemological beliefs may do better in tasks like writing research essays, but they may not necessarily perform well on standardized tests or high stakes examinations that can accomplished through traditional study methods. Research needs to be clear on what aspects of academic achievement is being measured. But the different understanding of what academic achievement means also poses a challenge to goals of epistemological research. For if less sophisticated epistemological beliefs are sufficient to attain high levels of academic results then it is hard to see why it is necessary for researchers to concern themselves with more sophisticated levels of epistemological belief. This problem is compounded by the fact that the current literature appears to be quite ambiguous about the prospects of achieving the highest levels of epistemological sophistication. For as some of the authors in this volume have noted the "evaluativist" orientation is very rarely observed or attained, even as other researchers claim otherwise.

21.3 The Constructivist Orientation

The difficulty with the relation between epistemological beliefs and academic achievement may have something to do with the constructivist orientation underlying much of the research in this field. For it seems to be the prevailing assumption that those with more sophisticated epistemological beliefs are also more constructivists in their orientation towards knowledge, and that this is a good thing.

Take, for example, the hypothetical case of the biology student presented in the chapter by Bromme, Kienhues, and Stahl. In characterizing the opposing orientations towards the study of biology, the authors maintain that the student would evince a "naive" epistemological stance if she "insisted that 'cholesterol,' 'risk,' and the 'cardiovascular system' should be conceived as real entities and not as theoretical notions under all circumstances." On the other hand, the student "would be sophisticated when she would be able to understand and apply different beliefs about knowledge within the biology course. For example she should be able to do her work in the lab based on the *fiction* of stable and certain entities within the cardiovascular system" (emphasis added). The authors further cite the work of Thomas Kuhn (1970) to support the contention that such epistemological flexibility is necessary for science.

But this account of the practice of science and the beliefs of scientists suggests further clarification. It may be the case that those who evince sophisticated epistemological beliefs would be able to work at the highest levels of scientific research. But this does not preclude the possibility that those with less flexibility may be able to do the same. There is indirect evidence that those who perform academic work at the highest levels may in fact regard knowledge in their field as quite stable. This comes across most clearly in Schommer's study in this volume on the epistemological views of practicing mathematicians.

We raise this point because it may turn out that the constructivist orientation that underlies the characterization of epistemological beliefs may turn out to be counterproductive. To put it somewhat bluntly, a student who approached biology or any other science from a constructivist point of view may not be able to do real science because he or she does not believe in it. Such a person, on the other hand, may have the ability to pursue the history or sociology of science. And as is well known the sociological view of scientific knowledge does not always accord with the view adopted by scientist and this incompatibility has been the subject matter of what has been called the "science wars."

In the study of school children in Israel, Tabak, and Weinstock observed that: "Ironically, though scientific thinking and religious thinking may be considered diametrically opposed, we believe that these two groups of students, those studying in the science-immersion program and those studying in a religious-immersion program convey a similar characteristic of epistemological-socialization." Students in both these domains were for most part disposed to a more absolutist epistemological orientation. In light of this similarity the researchers suggest that this may be due to the fact that the domains in question were regarded with deference or held in a privileged position that was not likely to be questioned.

In addition they also noted that "in both groups, in addition to absolutist positions, students also maintained multiplist or evaluativist positions, which shows that these students have the capacity to espouse what are considered more sophisticated epistemological positions." This observation, we believe, are quite important as they seem to indicate that the constructivist orientation may prevent, and perhaps even distort, what researchers are trying to capture with respect to the beliefs about knowledge and knowing.

It is also germane in this connection to ask: what are the epistemological assumptions that researchers hold with regards to their work? To what extent do the studies in personal epistemology evince the highest level of epistemological beliefs? Do researchers believe they are documenting actual experiences and beliefs of the people they study? Do constructivist researchers treat their conceptions as fictions? If so, how do they expect to persuade educators as well as policymakers to accept their prescriptions? Would they be obliged to appeal to some kind of pragmatic justification for the value of their studies?

21.4 Dimensions and Perspectives on Knowledge

The constructivist approach takes the view that the individual takes responsibility for constructing his or her own knowledge. This sometimes entails the view that all claims to knowledge are equally valid, although this is not likely to be a position that researchers in personal epistemology would be willing to endorse. But if all claims to knowledge are not equally valid, or if some claims are better than others, then what are the criteria or standards one could appeal to in order to justify one's claim to knowledge? We raise this question in order to ask whether the measures of both knowledge and knowing have been able to identify clear and objective standards to evaluate competing claims to knowledge. Have studies in domain-specific epistemologies been able to identify what constitutes criteria or standards for knowledge in various disciplines? As indicated earlier, there may have been attempts to treat knowledge from a psychological or sociological point of view that fails to do complete justice to specific claims of other disciplines. A poet and a scientist may have nature as subject matter, but a poem on nature is very different from a scientific theory about it. Different senses of knowledge and knowing are involved here, and one wonders if they are sufficiently captured by the prevailing concepts of epistemological research.

Even if the individual is responsible for the construction of personal knowledge, he or she cannot be responsible for all of his or her knowledge. As several studies in this volume have shown there is a sociological dimension to knowledge. No individual can possibly justify all of his or her knowledge claims. Accordingly, he or she has to rely on certain authorities; that is to say he or she has to trust the judgment of those authorities. In other words, trusting in authority is a fundamental aspect of our epistemological stance. But trust in authority is often correlated with a naïve epistemological position, whereas there are naïve and sophisticated ways of justifying one's reliance on specific authorities. And it is not clear if the prevailing concepts and measures have been able to capture this dimension of personal epistemology.

Similar considerations also affect the notion of whether knowledge is stable or changing. Researchers may take the view that those who hold the opinion that knowledge is absolute or unchanging tend to be more naïve. For example, many aspects of mathematics are fundamentally stable and unchanging. To be sure there are areas of mathematics that are controversial and evolving but these do not usually have any direct impact on our ordinary perceptions or understanding of the world. Furthermore, we need to distinguish progressive change from revolutionary ones. Only the latter alters our basic perceptions of the world. There have indeed been revolutions in scientific thought, as evidence by theories of relativity and quantum mechanics. The picture of the world based on these scientific theories may be bewildering, but this again does not normally affect our ordinary consciousness of the world around us. More importantly these revolutionary changes do not affect all aspects of our interactions with the physical world.

21.5 Measurement of Epistemological Beliefs

Some of the studies in this volume point to the importance of the distinction between actual and espoused or professed beliefs, and raise the question of the extent to which researchers are aware of the distinction or have been able to include it as a variable in their studies. According to Palmer & Mara:

> Previous research …indicates that students respond to the messages that teachers send to them about classroom expectations. For example, Schoenfeld's (1985) work shows that students may be aware of teacher's spoken expectations about what is important in the classroom (e.g., statements on syllabi, the benefits of group work) but may adopt such beliefs at only a rhetorical level rather than one of deeply held beliefs. He further indicates that students do not have difficulty espousing these rhetorical beliefs but acting (in classrooms) in completely contradictory ways.

It is not difficult to imagine that students could respond with behaviors they believe to be appropriate whether it corresponds with their domain epistemological beliefs or not. This difference between behavior and belief has been characterized by Limon (2006) as "enacted versus professed epistemologies." Chai and Khine (this volume) have also noted a similar discrepancy through their study of Singaporean pre-service teachers, who by and large expressed beliefs in a constructivist conception of learning but who were more didactic and teacher-centric in practice. As a consequence these researchers have been led to distinguish between espoused beliefs and beliefs in practice. A possible explanation for this discrepancy in the Singapore case may be due to the fact that student teachers are often expose to the rhetoric of constructivist pedagogy and therefore may be "playing to the gallery" in their responses to questionnaires.

Several possibilities open themselves to consideration as a consequence of this distinction. On the other hand it may be the case that teachers may be constrained by the structure of the curriculum to resort to traditional practices even though they do are more inclined towards constructivist pedagogical approaches. On the other hand, teachers may only be constructivist only at the rhetorical level. Different problems arise depending on which beliefs teachers actually subscribe to.

In the first case, the problem has to do more with the education system that limits the scope for teachers to apply their constructivist beliefs. This possibility points to the importance of epistemological studies to help advance the case for more innovative, student-centred teaching approaches. For these studies could show how the educational structure may impose limits on how teachers are able to teach and how students are able to learn. This is the case even for the USA in light of changes in its educational policies. As noted by Haerle and Bendixen, American teachers are increasingly losing their autonomy due to "standards-based education, high stakes testing, and teacher accountability." The "assessment culture" may be preventing teachers from putting their innovative beliefs into practice, and the same could be said of teachers in the Singapore case.

If teachers are constructivist only at the rhetorical level, then it would seem that either they are not convinced of its theoretical merits, or they are not convinced that it could be applied given the context of existing constraints. But this leaves open the question what teachers' beliefs are and how to establish them. The discrepancies between espoused belief and belief in practice may also reflect complex practical strategies that teachers have to adopt to balance their personal beliefs with institutional demands. These interactions may therefore require further research.

21.6 Characterization and Understanding of Learners

The range of students in epistemological studies spans the spectrum from elementary to graduate students pursuing doctoral degrees. In dealing with this range the research draws on basically two models of epistemological beliefs: one based on Schommer (1994), and the other on Hofer and Pintrich (1997). Both models include a development phase that begins at a naive stage that culminates in a higher sophisticated stage.

The development model seems to be reasonable given that most people do grow and mature in their thinking and understanding of knowledge. So it seems right to say that the sophisticated mode of belief about knowledge and knowing is the desired or preferred mode. Furthermore, the development stage would also seem to imply that younger persons would begin at the lower stage before progressing to the higher stages. But the studies in this volume show that this is not so simple. Buehl, for example, notes "contradictory findings across the range of investigations."

A study cited by Moschner, Anschutz, Wernke, and Wagener found that all children in the study between 9 and 12 years were able to verbalize their epistemological beliefs (invention, biological inheritance, God given, trial and error), ways to acquire knowledge (sensory perception, logical thought, personal experiences) as well as strategies to verify knowledge (investigations, logical thought, asking, looking it up, comparing different sources). Elder's (2002) survey of 211 fifth graders on science observed that the epistemological beliefs of children were "a mixture of naïve and sophisticated understandings." Another study by Kuhn et al. (2000) found that "even some 10 year old children show an evaluatistic level of epistemological understanding." Mansfield and Clinchy (2002) further claim that children "achieved the highest epistemological sophistication when issues were closest to their everyday experiences." Together these studies show that children even at elementary school seem to display developed cognitive capacities, while older students and adults sometimes evince less developed beliefs about knowledge and knowing in the course of pursuing advance studies.

Although the evaluativist stage is considered by some researchers to be rare, it said, in some studies, to have been attained by some high school students. And if some middle to high school students have reached the multiplist or relativist stage then it would seem they are no less advanced than many of their senior counterparts in university, right up to the graduate level. This would seem to imply that the characterization of students in terms of these dimensions may not capture or reflect the nature of their epistemological beliefs. A 14-year old and a 24-year old may be mulitiplist in orientation but not necessary in the same way or to the same degree.

It is not clear if existing measures are able to capture what might be significant differences in their beliefs. It may be that in answering questionnaires, students may understand the terms differently. They may be responding to different senses of the terms in the questionnaires, or they may have misunderstood them altogether.

As Moschner, Anschutz, Wernke, and Wagener put it:

> Do children have the ability to give abstract information about their beliefs and about their learning process? One of the implicit assumptions of questionnaire studies is that the subjects of the study are able to understand the items in the intended way.

Posing questions about science to elementary or middle school children may be especially challenging. What assumptions underlie researchers' beliefs about children's understanding of science? Can young children, for example, make clear epistemological distinctions between the sciences and the humanities, when even undergraduates may have difficulty specifying their differences? Can they say clearly what distinguishes science from mathematics? Is geography a science? These considerations bear on the way researchers characterize the epistemological foundations of various disciplines and inform the way they discriminate among domains of knowledge. And they have to be kept closely in mind in designing questionnaires. Problems with the wording of questionnaires and surveys are seldom reported but more attention should be focused on this part of the research on personal epistemology.

21.7 Beliefs and Cultural Contexts

Studies about cultural variation both within and across cultural contexts also reveal discrepancies that would require further clarification in the future. For example, the study of secular and religious schools undertaken by Tabak and Weinstock might be taken to mean that secular minded students differ in their epistemological beliefs from religiously minded students. The study shows religious beliefs do have considerable influence on the epistemological beliefs, so it is important to determine the extent of this difference within a given society or community.

In the case of Asian communities, the study by Youn (2000) showed that authority has influence on the epistemic beliefs of Korean students, a feature that is attributed to the national education context. Furthermore, in a study on mainland Chinese students, Qian and Pan (2002) revealed that Chinese students were more likely to view knowledge as simple and certain, and ability as innate. In the study of Hong Kong Chinese student teachers, however, researchers Chan and Elliot (2004) noted that these student teachers tended not to believe that ability was inborn and fixed, nor did they see knowledge as fixed and certain. Also these student teachers did not score high on the authority/expert knowledge scale. These studies show varying results about beliefs in knowledge and knowing.

Finally, the intercultural epistemological studies could also be used to explain a well-known contrast between East Asian and Western students. In terms of mathematics and science, students from East Asia have been known to do exceedingly well compared to their western counterparts. And if the researches reflected in this volume are fairly accurate then there may be distinct differences in the epistemological assumptions between these students. The question is whether these epistemological assumptions have anything to do with the performance of these students in mathematics and science. There is some evidence in this volume to support the claim that East Asian students may not be more sophisticated in their beliefs when it comes to mathematics and the sciences. But if this is the case then we return to a problem stated earlier about whether educators and policymakers would be interested to advance the epistemological beliefs of students when there is no evident relation between more sophisticated beliefs and academic performance. In this connection it may be important for researchers to consider the differences between East Asian and Western students in terms of the production of scientific and mathematical knowledge at the highest levels. For while school results of East Asian children are impressive, this alone might not translate in later life to a deepening interests in pursuing mathematics and science, or to abilities to contribute to the production of original knowledge at the highest levels.

21.8 Methodological Issues

In this volume, there are four chapters that focus on methodological issues. Among them, Schraw and Olafson's put forth a new instrument for the assessment of teachers' epistemological world views. They have piloted the instrument on 22 practicing teachers who attended a postgraduate course. The instrument requires participants to place themselves in one the four quadrants formed by two axles representing the ontological and epistemological dimensions underlying their world views. The axles form a continuum with the realist position on one end and the relativist on the other end. Theoretically, ontological beliefs and epistemological beliefs are closely related sets of beliefs. The idea of coupling and measuring of these beliefs with one instrument is therefore likely to spur some further development within the field. However, much developmental work is needed as the authors has noted. In addition to those mentioned by the authors, we propose that the instrument be tested with experts from various academic disciplines. Theoretically, scientists and engineers should adopt the position of ontological and epistemological realists, whereas certain humanities or social science disciplines would be more inclined towards the relativistic perspectives.

The other chapters that deal with methodological issues were contributed by Baxter Magolda, Beuhl, and Moschner, Anschuetz, Wernke, and Wagener. These chapters review methods of assessing epistemological beliefs developed to date. However, they differ in the ways they contextualize their contributions. Beuhl sets out to inform readers on the measurement of epistemological beliefs for diverse cultures, citing studies in which participants are mostly secondary or older students, while Moschner and colleagues review the measurement of epistemological beliefs and learning strategies among elementary school children. Despite the difference in their contextualization, both chapters describe a similar path of historical development of the measurement of epistemological beliefs. Prior to Schommer's Epistemological Questionnaire (EQ) (1990), researchers employed mostly interview as a method of data collection. The studies were interpretive in nature, describing a more or less comparable path of epistemological beliefs among adult (see Hofer & Pintrich, 1997).

It seems that the move toward quantitative assessment of epistemological beliefs has enabled epistemological beliefs studies to spread beyond adult participants to include wider audiences and correlations between epistemological beliefs and a host of other educationally important variables. However, the spread of EQ and other inventories have also revealed some crucial methodological problems inherent in this approach. With the employment of the EQ and its adaptation in other countries outside America, it is now clear that cross-culture replication of factorial structure is illusive (see Chan & Elliot, 2004; Clarebout et al., 2001; Youn, 2000). Beuhl's review highlighted the problem with the practice of incomplete reports among researchers. For example, it is not always possible for the readers to gain information about reliability of items or the factorial structure that emerged in a study. When information about reliability is reported, the coefficients seem to be low. It seems necessary for researchers who prefer to employ the questionnaires to review and construct newer instruments that would address the problems highlighted.

The trend within the field seems to be the diversification of methods that emerged due to further contextualization of this field of study. This development could be due to the rise of situated learning perspective. For example, to study students' epistemic thinking while they are engage in online search, Hofer (2004) employs think-aloud protocol. Schraw and Olafson's contribution in this volume can also be viewed as an example in terms of the way they contextualize epistemological beliefs within an epistemological world views among teachers. Hammer and Elby (2002) conceptualization of epistemological beliefs as epistemological resources activated based the demands of contexts is another example of this trend of development. Holschuh (2006) reported the use of scenarios as an assessment of epistemological beliefs. The results indicate that epistemological scenarios are a viable measure for assessing beliefs within a domain. In this regard, we would like to suggest that the current advancement of technology has much to offer in terms of capturing important data for the examination of enacted epistemology. Computers software can now be employed to capture students' interactions in small groups around the computers with actions on the computer recorded. Discussion forum that focuses on knowledge generation such as the Knowledge Building Community (Bereiter & Scardamalia, 2006) capture discourse data among students who are striving to establish knowledge advancement. With appropriate application of discourse analysis, researchers should be able to analyze natural data for the study on how students treat knowledge and how they come to know. Research in this area can further contribute to the advancement of contextualize understanding of how epistemological beliefs affect students learning activities.

21.9 Conclusion

Since Perry's (1970) inaugural study of personal epistemology, this field of study has progressed steadily over the past four decades. Today, empirical studies have investigated the epistemological profiles of a wide variety of samples employing diverse methods. Given the variety of studies, it seems almost inevitable for the research outcomes to be diverse and at times contradictory. Many researchers continue to note that challenges lie with measurement of epistemological beliefs because they are covert, and because effect of context or domain on beliefs is unclear. To consolidate understandings and to advance this field of study, it is clear that researchers in this field need to rise above by synthesizing the results obtained thus far and provide some form of coherent explanation for the diverse findings. The call of mixed methods approach by some researchers which could serve to triangulate and thus strengthened the findings and highlight the strengths and weaknesses of the methods employed, is also well warranted at this point of time.

References

Bereiter, C., & Scardamalia, M. (2006). Education for the Knowledge Age. In P. A. Alexander, & P. H. Winne (Eds.), *Handbook of Educational Psychology* (2nd ed.). (pp. 695–713). Mahwah, NJ: Lawrence Erlbaum.

Chan, K. W., & Elliot, R. G. (2004). Relational analysis of personal epistemology and conceptions about teaching and learning. *Teaching and Teacher Education*, 20, 817–831.

Clarebout, G., Elen, J., Luyten, L., & Bamps, H. (2001). Assessing epistemological beliefs: Schommer's questionnaire revisited. *Educational Research and Evaluation*, 7(1), 53–77.

Elder, A. D. (2002). Characterizing fifth grade students' epistemological beliefs in science. In B. K. Hofer & P. R. Pintrich (Eds.), *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 347–363). Mahwah, NJ: Erlbaum.

Hammer, D., & Elby, A. (2002). On the form of a personal epistemology. In B. K. Hofer & P. R. Pintrich (Eds.), *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 169–190). Mahwah, NJ: Erlbaum.

Hofer, B. K., & Pintrich, P. R. (1997). The development of epistemological theories: Beliefs about knowledge and knowing and their relation to learning. *Review of Educational Research*, 67(1), 88–140.

Hofer, B. K. (2004). Epistemological understanding as a metacognitive process: Thinking aloud during online searching. *Educational Psychologist*, 39(1), 43–55.

Holschuh, J. P. (2006). Assessing beliefs: The epistemological scenario. *Academic Exchange Quarterly*, 10(2), 172–175.

Kuhn, T. S. (1970). *The structure of scientific revolutions*. Chicago, IL: University of Chicago Press.

Kuhn, D., Cheney, R., & Weinstock, M. (2000). The development of epistemological understanding. *Cognitive Development*, 15, 309–328.

Limon, M. (2006). The domain generality-specificity of epistemological beliefs: A theoretical problem, a methodological problem or both? *International Journal of Educational Research*, 45, 7–27.

Mansfield, A. F., & Clinchy, B. (2002). Toward the integration of objectivity and subjectivity: Epistemological development from 10 to 16. *New Ideas in Psychology*, 20, 225–262.

Perry, W. G. (1970). *Forms of intellectual and ethical development in the college years: A scheme*. New York: Holt, Rinehart & Winston.

Qian, G., & Pan, J. (2002). A comparison of epistemological beliefs and learning from science text between American and Chinese high school students. In B. K. Hofer & P. R. Pintrich (Eds.), *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 365–386). Mahwah, NJ: Erlbaum.

Schoenfeld, A. H. (1985). Students' beliefs about mathematics and their effects on mathematical performance: A questionnaire analysis (Publication no. ED259950) from Eric Document Service.

Schommer, M. (1994). Synthesizing epistemological belief research: Tentative understandings and provocative confusions. *Educational Psychology Review*, 6(4), 293–319.

Youn, I. (2000). The culture specificity of epistemological beliefs about learning. *Asian Journal of Social Psychology*, 3, 87–105.

Author Index

Subject Index