Kenneth Y.T. Lim *Editor*

Disciplinary Intuitions and the Design of Learning Environments

Springer

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The former elevator in the Gutman library at the Harvard Graduate School of Education before the renovation of the latter in the fall of 2011

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Editor
Kenneth Y.T. Lim
National Institute of Education
Nanyang Technological University
Singapore, Singapore

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To God be the Glory
and…
thank you, Granddad ☺

Foreword

I was especially pleased to receive the invitation by the editor and contributing authors of this book to walk with them in this journey they have christened Disciplinary Intuitions.

Academic endeavour is always a palimpsest of sorts, with succeeding generations of researchers and authors standing on the shoulders of giants. This is particularly so when the endeavour in question is conceptualising, making the case for, and illustrating examples of a field of study hitherto uncharted. In this regard Kenneth should be highly commended for fulfilling his editorial responsibilities – it could not have been easy to put together a team of academics and researchers representing such a diversity of experience, disciplinary expertise, and sheer writing talent that he has.

To say that he has pulled it off, and pulled it off with panache, would be an understatement. Together with his team, they have drawn from more than 300 bibliographic references from a variety of disciplinary domains – ranging from cognitive psychology, early Chinese philosophy, to the natural sciences – to make a compelling case for Disciplinary Intuitions as a theory of learning. From the foundations laid in Part I of the book, the authorial team responsible for Part II offers some very practical and actionable pointers for thinking about existing curriculum structures from the perspective of Disciplinary Intuitions, with a view to crafting authentic experiences for learners of all ages.

In my own work, I have written a little about how the sociocultural dynamics of the present century – mediated as they are through, inter alia, the Internet of things and social media – are working themselves out through a collective substrate my authorial colleagues and I have come to call the Networked Imagination. Through the lens of the Networked Imagination, Disciplinary Intuitions offer some intriguing

provocations to looking anew at the assumptions, structures and enactions of much of what constitutes curriculum design. It remains only for me to invite you to navigate this exciting landscape with the authors of this book.

John Seely Brown
Visiting Scholar at the University of Southern California
Los Angeles, CA, USA
Independent Co-chairman of the Deloitte Center for the Edge
Silicon Valley, CA, USA

Preface

When I was a lad of about five, my grandfather – God bless his soul – would take me to the airport in the afternoons. This was in the early 1970s, and it was a wonderful time to be exposed to the sights, sounds and smells of civil aviation. Pan Am had just started Boeing 747 services to the Far East, and a highlight of my (almost) daily visits would be scanning the horizon for the earliest indication that that wondrous double-deck white and blue aircraft was on final approach to Paya Lebar, Singapore.

These visits to the airport continued into my primary school years, and somehow granddad and I would always find time to sneak away from home to fill our lungs with wafts of jet fuel. Things got really exciting when British Airways and Singapore Airlines started joint services to London via Bahrain on the supersonic Concorde; memories of that pencil-thin fuselage with its amazing delta wing and thunderous afterburner-charged roar seem as fresh in my mind today as they were forty years ago.

Yes, on a busy day, the apron at Paya Lebar would be filled with all manner of aircraft of different shapes and sizes – from the 747 to Concorde and almost everything conceivable in between. As a young boy, these repeated visits to the airport left an indelible impression upon me and left me wondering how each of these aircrafts – regardless of their differing propulsion systems, wing shapes, fuselage configurations, sizes and weights – could somehow all *fly*.

So it was on a diet of Ladybird books and engaging granddad in conversation that as a young boy I learnt about principles of chord design and fluid dynamics way beyond my grade level and about lift, thrust, drag and weight and about yaw, pitch and roll. Through the pages of those books, these complex relationships were explained in terms that I could understand, with nary a 'Bernoulli' or a 'resultant vector' in sight. It wasn't until I entered secondary school at the upper grade levels that I learned about such codifications of canonical knowledge in mathematics and physics lessons. By then, of course, it all made so much sense to me because I was finally able to explain – using epistemically appropriate discourse structures – the stuff that I had seemed to just 'know' all along.

I first started thinking about the disciplinarity of intuitions in early 2011. The ideas were precipitated through a series of discussions with teachers who were reflecting on lessons which they had been conducting using immersive environments

over the preceding two years. The lessons had been designed using a framework that I had designed (the Six Learnings curriculum framework) and had been yielding results which the teachers were happy with, not only in terms of grades but – just as importantly – in terms of 'softer' observable aspects such as the dispositions of students towards learning. Through the discussions, the teachers and I were trying to put our finger on why the lessons were 'working'.

It took us a bit of time to come to the realisation that the approach was working because it was affording the students opportunities through which to develop and surface nascent and tacit intuitions about the respective domains, and this – in turn – was laying the foundation for more enduring first-principle understanding.

From these early beginnings, my colleagues and I formed a reading group in May 2012. We soon realised that there was a field at the nexus of curriculum, learning, practice and psychology which was ripe for investigation, and we approached Springer with a proposal to lay the foundations for this. We were awarded a contract that November, and the authors of this book worked hard to ready the manuscript and meet our deadlines.

Just like this trip down memory lane, this book also begins with the story of a young boy. The book itself is divided into three parts, with Part I laying the theoretical and historical foundations for Disciplinary Intuitions. In the first chapter of this book, Hung and Lyna introduce us to Nathan and his adventures at the local bowling alley, as he auditioned for and eventually trained as a member of his school bowling team. Through his story, we come to have a clearer appreciation of the interplay between the individual and his or her social others, particularly from the perspective of embodied cognition.

If you'd like to know more about the theoretical foundations of Disciplinary Intuitions, then continue reading Chapter 2, as Tan and I explore the nature of intuition and the disciplinarity thereof. We take a stand against the prevailing tide of interdisciplinarity and concludes the chapter by submitting for the reader's consideration the case for what the authors of this book have come to refer to as Disciplinary Intuitions, as a theory of learning. We then hand the baton to Yuen, who traces intuition from the perspective of the classical Chinese philosophy. A second Tan continues the theoretical narrative and – in Chapter 4 – gamely frames the philosophical arguments from the preceding chapters through the lens of practice, specifically the lens of constructivism. By doing so, she helps us understand how the Disciplinary Intuitions approach to learning and curriculum design stands distinct from existing literature on misconceptions.

Part II of the book takes the concept of Disciplinary Intuitions and applies it to various disciplinary domains. Thus, for example, both Tans collaborate in Chapter 5, in which they revisit some of the theses from the preceding four chapters and recast them specifically with a focus on the nature of intuitions in the natural sciences.

Chapter 6 sees Mohamed Suffian introducing us to his intervention with students of the subject known as design and technology in the Singapore curriculum, in which the intuitions of young learners with respect to the way complex forms might be deconstructed into their constituent primitives are explored and mediated.

In Chapter 7, I address you – dear reader – directly, as I share my thoughts on Disciplinary Intuitions as they relate to the domain in which I received my initial academic enculturation, namely, geography. We return to the theme of travel and I take you on a whirlwind tour of the world – from the Nile to the Hawaiian archipelago – so hold on tight and bring your passport.

After that world tour, you might have the taste to pick up a new language. Together, Yin and Paul weave a finely crafted narrative of the nature of intuition in language learning. As you might imagine, this is an expansive topic, and that is why the two authors have chosen to address this in no fewer than three chapters, namely, Chapters 8, 9, and 10.

Chapter 11, picks up the storytelling theme and recasts it in quite an unexpected and refreshing direction – the chapter is written by Lee and Chia, who as my interns are the two youngest contributors to this book; as you'll see for yourself, their youth belies their conceptual discourse.

In Chapter 12, Cho and Hong continue with stories, as they weave a fascinating tale which literally tells stories in mathematical intuition, using examples from the Korean education.

Part III of the book represents a coda to the preceding chapters. Chapter 13 is a thinkpiece by Baildon, who draws from his vast experience in the classroom and from his own scholarly understanding, to artfully synthesise many of the strands introduced by the various contributing authors in the preceding chapters through the lens of the social sciences.

Last but certainly not least, we end this book on Disciplinary Intuitions with Howe's eminent contribution in Chapter 14, as she draws the entire book to a coherent and convincing close using her established research trajectory from the natural sciences. Going out with a bang, and true to our combined stance as members of the authorial team, the concluding chapter of this book dialectically couples theory with practice and the two with implications to policy.

The book may conclude there, but for your online reading pleasure, please feel free to browse http://sites.google.com/site/disciplinaryintuitions/ as – in many ways – the story of Disciplinary Intuitions has only just begun. On behalf of my authors, I am very pleased to share with you our thoughts on Disciplinary Intuitions as a theory of learning.

Granddad passed away many years ago, and the airfield at Paya Lebar is no longer used for civilian traffic. The world is a very different place from where it was in the early, pre-oil crisis, the 1970s. Some of the promises of that era have still not yet been fulfilled. But whenever I step into an airport departure lounge, I remember that five-year-old boy from (not) so long ago and think of granddad and those trips to the airport.

Singapore Kenneth Y.T. Lim

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On a personal note, I would like to thank each of the members of my own research team for their patience and diligence; they are Yuen Ming De, Ahmed Hilmy, Derek Chua, Collin Chan, Richard Lee, Gabriel Chia, Joel Ng and Tan Keng Swee.

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About the Authors

Mark Baildon is an Associate Professor and Head of Humanities and Social Studies Education, National Institute of Education (Singapore). With James Damico, he is co-author of *Social Studies as New Literacies in a Global Society: Relational Cosmopolitanism in the Classroom* (Routledge, 2011) and co-editor of *Controversial History Education in Asian Contexts* (Routledge, 2013). He has published on social studies and literacy education in several journals and helped create the Critical Web Reader (CWR), a comprehensive set of Web-based inquiry, literacy and technology tools designed to guide teachers and students to engage strategically with Web-based texts. He is also co-editor of the online journal *HSSE Online: Research and Practice in Humanities and Social Studies Education***.**

Gabriel Chia aims to complete his GCE 'A-'Levels in 2014. He has a wide spectrum of interests in the arts and hopes to venture into the visual arts industry, as well as write his own book one day. Gabriel is also a book and video game enthusiast, spending his free time on weekends reading books and playing computer games. Because of these interests, he took part as an intern in the 2013 Nanyang Research Programme to design a study on the role that game-based worlds and immersive environments potentially play in learning.

Young Hoan Cho is an Assistant Professor in the Department of Education at Seoul National University, South Korea. He received a Ph.D. in Information Science and Learning Technologies from the University of Missouri in 2011. He worked as a Research Scientist in the National Institute of Education, Singapore, from 2011 to 2013. His research interests include student-centred learning, collaborative learning, multimedia design, online learning environments and new technologies.

Ming De Yuen is a Research Assistant at the National Institute of Education in Singapore. He is interested in exploring the thoughts of the early Chinese philosophers, specifically thinkers from pre-Qin period, commonly referred to retrospectively

as Confucians, Mohists, Daoist and Yangists. Ming De holds the assumption that 'ethical thinking' existed in early China and that the early thinkers put forth and defended their individual theories on the ideal life. His first set of concerns is understanding how the early philosophisers defended their theories and what arguments or persuasive methods were employed. His second set of concerns is to investigate and elaborate on the underlying assumptions that implicate the differences and disagreements between these various thinkers.

Seo Yon Hong graduated from Seoul National University with a master's degree in Educational Technology. Her thesis concentrated on the components and process of learner-generated visual analogy. Her research interests lie in the area of instructional design with a focus on problem solving, constructivist learning environment and human visual intelligence.

Christine Howe is a Professor of Education, Cambridge. She is a developmental psychologist, whose research lies at the interface between psychology and education. Her main interests are children's conceptual knowledge, particularly in the domains of science and mathematics, and children's peer relations and communicative competence. For the past 20 years, she has also been bringing the two interests together, via research and consultancy on 'interactive learning' in peer group and tutor-led and computer-mediated settings. As well as resulting in numerous publications and research grants, Christine's research on collaborative learning in science has attracted considerable media attention and has had significant impact on policy and practice.

David Hung is a Professor of the Learning Sciences and an Associate Dean of Office of Education Research, National Institute of Education, Singapore. His teaching and research interests relate to social cultural orientations to cognition and communities of practice. Professor Hung has conducted research in learning and instructional technologies, constructivism and social constructivism and learning in communities of practice. He is currently a contributing editor of Educational Technology. He is also an honorary consultant to the Educational Technology Division, Ministry of Education, Singapore.

Richard Lee resides in Singapore and studied at the NUS High School. He holds a great interest in statistics as well as in computational problems and aspires to be a teacher in Singapore. As part of the Nanyang Research Programme organised by the Nanyang Technological University in 2013, Richard had worked under a mentor in the National Institute of Education faculty (Kenneth Y. T. Lim) to research on how visual novels have promoted active learning.

Kenneth Y.T. Lim is a Research Scientist at the Centre for Research in Pedagogy and Practice, National Institute of Education, Singapore. Prior to his appointment, he taught geography and social studies in several schools and junior colleges in

Singapore, as well as served as a Curriculum Designer in the Ministry of Education. His doctoral research was on adolescent spatial cognition, and his present research interests lie in maker movements and the affordances for learning of fictive worlds and virtual environments. As a theory of learning, Disciplinary Intuitions undergirds his work in schools in Singapore.

Lyna currently works as a Research Fellow at the National Institute of Education (NIE), Sicngapore. She obtained her Ph.D. degree in science (Physics) education in January 2009 from the NIE. Before pursuing her Ph.D. degree, she was a Deputy Head of Physics Department, Faculty of Teacher Training and Education, at a Catholic University in Surabaya, Indonesia.

Anselm Premkumar Paul is a PhD student with the Learning Sciences and Technologies Academic Group from the National Institute of Education, Singapore. Anselm graduated from the University of Melbourne with an honours degree in Computer Science. After having worked for 2 years as a Software Engineer, he heeded the call to teach. He has since served in education passionately for the last 12 years with five of these heading the English Language and Literature Department at a secondary school in Singapore. His research interests include personal epistemology, dialogism, technologies for learning, teacher professional development for ICT and his three daughters.

Mohamed Suffian Bin Mohamed Amin is a Design and Technology (D&T) teacher in Zhonghua Secondary School. Throughout his teaching career, he has been actively involved in curriculum planning, review and professional development of D&T educators in Singapore. He has collaborated with the Ministry of Education of Singapore (Sciences Branch, D&T unit) and Nanyang Technological University (National Institute of Education, Natural Sciences & Science Education, D&T Education) on many curriculum innovation projects. In addition, he is a member of the D&T Subject Chapter, a committee that promotes professional excellence amongst D&T educators in the Academy of Singapore Teachers. His research interests are in the area of D&T, pedagogical content knowledge and critical and creative thinking skills through non-verbal mode of representation (sketching). His teaching qualifications include a Master of Education specialising in Curriculum and Teaching, a Postgraduate Diploma in Education and a Bachelor of Engineering (Hons) from Nanyang Technological University (NTU).

Michael Tan is a Research Scientist at the Centre for Research in Pedagogy and Practice, National Institute of Education. A recent graduate of the Ontario Institute for Studies in Education, Michael's interests are in the potential for schools to change society and, concomitantly the sociological effects of an unequal distribution of knowledge. He is a strong believer of the liberatory potential of education and is currently interested in aspects of embodied cognition as a means to rethink conventional approaches to curriculum and instruction.

Michelle Tan is an independent scholar based in Vancouver. She situates her work between policy and practice. She is actively involved in continuing teacher education and curriculum reform research.

Bin Yin holds a Ph.D. in linguistics from the University of Southern California and is currently working as a Research Fellow at the Centre for Research in Pedagogy and Practice, National Institute of Education (Singapore). His main research interests are second language acquisition and language processing.

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Part I
Theoretical and Historical Foundations

Chapter 1
Intuitions All Around Us

David Hung and Lyna

> …Every function in the child's cultural development appears twice: first on the social level, and later on the individual level; first between people, and then inside the child. (Vygotsky 1978, p. 57)

Introducing Nathan

Have you ever observed someone learning to bowl?

We have. Thanks to funding generously provided by our university, in 2013 we had the privilege of working with a school in Singapore to conduct a study documenting the progress that a member of the school's bowling team made, as he was inducted into the sport. The study has enabled us to gain insights on what goes on in the young bowler's mind as he lines up his ball and aims for the pins. Along the way, we have learned about reflexes, metacognition, and – yes – intuition.

Ten-pin bowling demands excellent ball sense and the ability to read lanes. A typical bowling lane has 40 boards. Bowlers take different standing positions on these boards on the lane. There are ten frames for each game. Each frame consists of two throws. The first throw is usually done with a reactive ball. If there is no strike (all pins down), a spare throw is needed. A spare is usually thrown with a nonreactive spare ball. The case focused on detailed observations and data collection at the individual and social levels. A 13-year-old student, referred to as Nathan, from the team was chosen for in-depth observations over a 4-month period. This enabled the documentation of how social- and individual-level affordances were intertwined.

D. Hung (✉)
Office of Education Research, National Institute of Education, Singapore, Singapore
e-mail: david.hung@nie.edu.sg

Lyna
Centre for Research in Pedagogy and Practice,
National Institute of Education (NIE), Singapore, Singapore
e-mail: lyna@nie.edu.sg

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Nathan started bowling when he was 9 years old and was part of his primary (elementary) school team. Upon graduating from primary school, many of his classmates continued to bowl in secondary (middle) school. Nathan did not follow this trajectory, as his new school did not offer bowling as a cocurricular activity.

The ability to follow Nathan's transition from primary school to secondary school was an important element of this study. The transition offers insights on Nathan's action-performance from having social supports to one in which he created his own pseudosocial support. The first author was in the position to document rich data about this transition. Nathan was continually asked to express his feelings about his performance in bowling. Such engagement with Nathan enabled comparisons between pretransition and posttransition data. The second author acted as a critical peer in refining the data and in avoiding bias. Together their observations were painstakingly discussed with Nathan; the iterative approach was slow but necessary.

Cognition and Action at the Individual and Social Levels

Yin's (1994) case study approach was used. The approach is preferred when there is a need to ask "how" and "why" questions which focus on actual situations and events. As such, generalizability was not a focus of the work reported here. Instead, we sought to investigate the social and individual relationships and articulate the kinds of mediations that enable both social and individual levels to be integrated and intertwined. Thus, our observations focused on the richness of participant's learning contexts, interactions, and interactants at the social level. Field notes about the learning contexts were collected. Interviews and observations were also conducted with the coach, counselor, and community members who had interacted with the participant. We adopted a historical and developmental approach through a case study to trace the interdependent relationships between the social and individual levels of cognition and embodied action. Interview transcripts, field notes, images, and documents formed the bulk of the data collected. The analysis consisted of multiple readings of the collected data. It generated a set of recurring themes which drew us to the work of Csordas (2008) and Marratto (2012). The latter has coined the term intercorporeality to describe phenomena of collective social action.

What Mediates Between the Individual and Social Levels?

Based on our observations, we have identified three kinds of mediation artifacts for individual and social levels of cognition and action – thought, embodied action, and affect. These artifacts can be represented respectively in language, multimodal actions, and emotions such as confidence or frustration. The subtlest artifact is affect since it is usually intuitive to the individual mediating his thought and action.

We argue that embodiment is implicit in the transitive process from learned skills and scientific concepts to spontaneous concepts (Vygotsky 1986). Such intuitive understandings are gained from contextualized experience. Feeling confident in a situation can be very powerful and one usually reacts to a situation because of familiarity. However, not all contexts are identical, and often in bowling, young participants may have tacit confidence in a particular competitive situation by identifying with similar experiences in the past. However, because of changing lane conditions, such affective sensing can be misleading and hence need to be recalibrated from time to time.

Purpose and perseverance are likely gained through social encounters and experiences; for example, through sociocognitive apprenticeship construction (Collins et al. 1989) in which part of the learning takes place by observing and imitating experts, and through shared stories. It is important to note that if a community values a particular achievement, it would manifest such value in various observable actions and reifications.

In the case study, Nathan had a strong team community when he was in elementary school. He often competed in a peer network. When Nathan entered secondary school, his motivations to compete were observed to be declining. While there is a larger community of bowlers in Singapore, the actual relationships and recognition of team spirit and responsibilities toward the team are an important social-level phenomenon. In other words, the perceived team spirit, mediated by perceived commitment and the psychological and emotional desire to win for the school, has a dialectical effect on the individual players. Jamaludin et al. (2012) have described this phenomenon as socioregulation – the perceived collective as a social phenomenon and as it relates to individual actions and decisions.

Cognition and Action at the Level of the Social

Nathan was taught canonical solutions by his coach. He initially trusted the recommendations in that his backswing was conjectured to be the cause of his inconsistency, which capped his average score around 160. [Note: In 10-pin bowling, the maximum score is 300.]

While Nathan's coach assured him that with his skill set he should have little difficulty averaging around 180, in reality he was not experiencing this. When he played on his own, he found that his average dropped to 150, and he became less confident on the bowling lane. Nathan was frustrated and confused.

Because Nathan's coach was not always available, Nathan's father (acting as a counselor) played a "problem-solving" role. Nathan's father worked with Nathan to analyze situations and work toward the 180 goal that the canonical solution predicted. Encouraging Nathan not to give up, Nathan's father systematically recorded his games and replayed the videos for Nathan to assess his own performance.

Table 1.1 suggests how mediation between individual- and social-level cognition and action influences intramental (Vygotsky 1978), intermental (Vygotsky 1978),

Table 1.1 The mediation of cognition and action at the individual and social levels

At the individual level	Mediation	At the social level
Purpose and goals	Thought	Context
Personal goals and motivations	Statements of motives and goals	Competitions as a collective phenomena
Desiring to achieve a goal with a reasonable chance of winning	Reasoning on what to do	Social others expressing enthusiasm
	The hypotheses of others	Expressions in social / mass media
Problem-solving	Action	Canon
Analyzing problems	Observable performance	Learners need to make sense of different approaches and draw their own conclusions
Realizing one's weakness	Observable social supports	
Finding solutions		
Using aids to thinking and action		
Personalizing	Affect	Counselor
Making it one's own	Feelings arising from innate reactions	Coach to guide skill
Figuring out	Feelings of "rightness" about choice of resources as a result of phenomena consequences or feedback	Critical friend to aid in thought and rationalizing of theory in practice
Appropriating to one's own strengths and weaknesses	Feelings of frustration on experimentation	Aiding in the forming of personal theories
Forming personal theories		Encouraging the learner to persevere and have confidence
Perseverance		Community
Not giving up when confused		Stories
Being inspired by the struggles of others		The experiences of others
		Socio-cultural history
		Peer support and team spirit

and intercorporeal (Csordas 2008; Marratto 2012) processes, respectively; such artifacts of mediation might be thought of as either in situ actions that are observable by others or as recordings of one's actions, which mediate subsequent thought, action, and/or emotion.

Nathan worked together with his father within this authentic Zone of Proximal Development (ZPD) in trying to attain an average beyond the current level. Nathan's father subsequently observed that when Nathan was under his coach's guidance, he could usually perform. For example, when the coach was training Nathan's sparing (the second shot per frame of bowling), he was able to swing and release the ball accurately. But when he was playing in "game/competition mode" – during which

there were some differences between the first and second swings and releases, Nathan did not seem to switch well. This enabled Nathan's father to suggest that his likely problem was his inability to switch. This meant that Nathan's body momentum/muscle memory with his first swing caused him to swing his spare swing inaccurately. The swing for a spare (subsequent throw) should be as simple as possible in order to keep a straight throw. This is different from the first swing with the reactive ball (which caused the ball to weave and swerve). It took a while for Nathan to acknowledge this observation, mediated by the recordings.

At this stage, Nathan's father brainstormed with Nathan what he could do in such a situation – assuming that the first swing confused him with respect to his second swing and his body could not adjust optimally. The dialogic process resulted in the possibility of sparing the pins with his reactive ball while using his first swing approach, and using his spare ball (least reactive ball) for pins such as "pin 10," which could not be spared unless the ball (spare ball) was relatively straight. This solution was indeed a "mix and match" of the different approaches which bowlers usually adopt instead of mechanically applying canonical solutions.

With this newly formed hypothesis, Nathan tried sparing with his reactive ball, interspersing between his reactive and spare systems. On his first attempt, he scored 150. That evening he visited a bowling store, and he shared his frustrations with an attendant. He was told a story about how a top bowler had a breakthrough in one competition when he played 26 games in one event. Nathan decided to play many games on that day hoping for a breakthrough. Nathan repeatedly said: "Let me figure out." The next day, Nathan decided to try out his "mix and match" approach again, figuring out what worked best for him.

From the preceding description, social and individual levels are inextricably interconnected. As depicted in Table 1.1, the social-level dimensions included the:

- Context of competitions which Nathan desired to do well in
- Canonical solutions which he sought help on to address weaknesses
- Coaches and social others whom he sought advice from (the bowling community)
- Counselors (in this case, Nathan's father) who acted as "by the side" problem-solvers in helping to learn within an authentic ZPD

Cognition and Action at the Level of the Individual

Nathan needed to construct a purpose for continuing his bowling, especially when the training regime was quite difficult and required resilience. Moreover, Nathan needed to know how to engage in a problem-solving process to figure out his weaknesses – in a nonstructured process – and to work out solutions by appropriating the ones that would work best for him. This figuring-out process was far from straightforward as it requires a balance of receptivity (i.e., listening to others' views and feedback) and struggling to see results in terms of performance. As there were many

views and much feedback, Nathan needed to assess for himself and make his own, by choosing what would work best for him through trial and error. In other words, Nathan had to personalize a solution which made embodied sense. This personalization process is consistent with Bakhtin's (1981, 1986) notion of how one has to populate one's thoughts with others' ideas and experiment with others' ideas. This process of making "one's own" is realized in thought and action. Although personalized understandings when reified in terms of procedures and principles appear similar in an artifact representation, Nonaka and von Krough (2009) have characterized this as the tacit knowledge dimension. As depicted in Table 1.1, the individual-level dimensions included:

- Goal-setting in motivating and guiding oneself to attain the desired end goal
- Systematic problem-solving by using aids for thinking and actions
- Personalizing situations by appropriating ones' strengths and weaknesses
- Persevering during difficult times and believing in oneself

Embodiment and Confidence-Building Through a Zone of Proximal Development

"Learning in the ZPD involves all aspects of the learner – acting, thinking and feeling" (Wells 1999, p. 331). We use this expanded notion of ZPD to illuminate the complexities of learning when thought, emotion, and action-performance are synthesized.

In the case study, the presence of social others aided the learning of the student; for example, his coach and counselor aiding him to think and reason, giving some examples (role models), observing his physical performance, and encouraging him. Thus, the social level was characterized by mediational artifacts such as words of advice, recordings of performance, and pointing out areas of improvement. These enabling social supports and activities aided Nathan's performance. The ZPD goal for Nathan was to help him fix his weaknesses. This fix was a skill-related competency. Nathan had to straighten his backswing and improve on sparing.

There is another "fix" which takes more than an instructionally related ZPD to enable a higher average. This second fix is namely his confidence during competitions. Confidence and bowling at one's optimal state during competitions would require more exposure to different competitions for the learner to learn how to cope with the stress and atmosphere of the social context and environment.

We argue that this confidence is expressed as an evolving emotional artifact developed from extensive exposure to competitions. Confidence in choosing a ball is not just conceptual because it is "intuitive" to use a particular ball. In practice, bowlers need to have experiential confidence in selecting tools and resources.

In the interviews, Nathan mentioned that he struggled much with managing the difficulty of changing lane conditions. We also noticed other more experienced boys struggling as well. Nathan commented:

> I almost wanted to give up after my first two games…. I felt that I should not do competitive bowling, but just to do it leisurely…. [W]hen I was in the school team last year (in primary school), I was a lot more competitive. But now I feel that I am no longer competitive.

The context of Nathan's statement helped us understand that the feeling of being in the school team influenced him significantly in desiring and motivating him to compete and do well. This point reiterates the critical role of the coupling between the community and the individual with respect to the motivation of the latter.

Lensing the Individual and the Social

Activity theory (Engestrom 2006; Nardi 1996; Yamazumi 2008) can be a lens to the social environment in that all activities are goal-oriented, as defined by the collective. Bakhtin (1986) refers to mediation through others as dialogism. The latter involves the interpretation of perspectives or meanings about symbols used by others, a process which Bakhtin has termed "appropriation" – "take the word, and make it one's own" (Bakhtin 1981, p. 294). Intersubjectivity is established at the intermental level between members and the division of labor amongst members in order for the collective to perform functions relative to the goals. This process requires social adaptation for members to find their respective roles and determine the points at which their respective contributions are most productive. Bandura (1977, 1986) has emphasized the importance of observing and modeling the behaviors, attitudes, and emotional responses of others in learning.

There is a dialectical interaction between thought and action, which describes the mediational process at the intermental level (Alibali and Nathan 2012). We hypothesize that word-to-action dialectical translation is not a direct effect but one which undergoes much adaptation in making it one's own (Bakthin 1981).

Consistent with an embodied cognition perspective, thought, feeling, and action are inseparable (Cole 2000; Damasio 1999). From our observations of performances requiring motor coordination, the translation of word-to-action is complex and iterative. Translation enables tacit, intuitive knowledge (Polanyi 1966) to form, which is not necessarily language-related but defined by an action-performance discourse. Established concepts become spontaneous concepts (Vygotsky 1986) as the former are embodied through experience and made one's own. The overarching issue of embodied cognition is a reciprocal relationship between thought and action (Maturana and Varela 1992).

Just as there are at the individual level of analysis, there exist spontaneous concepts as collective performance. For example, how raids are planned and enacted within the Massively Multiplayer Online Role-Playing Game *World of Warcraft* (Jamaludin et al. 2012) are instances of the community leveraging the embodied understandings of members with respect to their respective roles (spontaneous concepts) in a collective effort. When this collective reflects on intercorporeal group-raid performances, the group begins to develop tested understandings of how it

approaches different situations. We recognize these as consistent with scientific concepts at the social level of analysis.

Mediation: Interactions Between Individual and Social Levels

The interactions between individual and social may be described by the concept of mediation. Mediation is usually viewed in terms of how it enables actions. Bruner (1986) has reminded us that actions are mediated through negotiation with others. It is this understanding that enables further appreciation of the ZPD. Wertsch (1995, 1998) has observed that for Vygotsky, mediation meant linking the social and individual, connecting the external and internal. Kozulin (1998) and Wertsch (1995) have remarked that Vygotsky did not elaborate much on the activities and emotions of humans as mediators. Instead, the issue of emotion for Vygotsky (1987) was reflected only in the concluding pages of *Thinking and Speech*, in which Vygotsky explores the dialectical, intertwining relationships between thought, affect, language, and consciousness in the following quotation:

> [Thought] is not born of other thoughts. Thought has its origins in the motivating sphere of consciousness, a sphere that includes our inclinations and needs, our interests and impulses, and our affect and emotions. The affective and volitional tendency stands behind thought. Only here do we find the answer to the final 'why' in the analysis of thinking. (Vygotsky 1987 p. 282)

John-Steiner's (2000) research on creative collaborations similarly explores the relationships "between thought and motive, and cognition and emotion" (2000, p. 218). Much of the work revolves around how confidence can be appropriated when participants engage in joint activity and collaboration. As Luria (1987) pointed out in the afterword of *Thinking and Speech*, Vygotsky focused on this affective aspect of learning:

> Without the exploration of the relationship of the word to motive, emotion, and personality, the analysis of the problem of 'thinking and speech' remains incomplete. The relationship between meaning and sense, and the relationship of intellect to affect, were the focus of much of Vygotsky's work in the last years of his life. (p. 369)

We emphasize a theoretical middle ground where cognitive and mental development is embedded within the contexts of society, community, and culture; and where learning is an ongoing process of transaction between individuals and their social contexts (Arievitch and Haenen 2005; Rogoff 1994; Wertsch et al. 1995); in this middle ground, affective and emotive aspects are of prime importance for learning (Boekaerts 2003). A study from neuroscience by Immordino-Yang and Damasio (2007) reveals that persons whose cognitive skills are intact, but emotional responses are damaged (i.e., having problems with social emotions) are no longer able to perform social cognition (e.g., to select the most appropriate response in social situations, to learn from feedback on their behavior). It indicates that although their cognition was intact, "their reasoning was flawed because the emotions and social

considerations that underlie good reasoning were compromised" (p. 5). Accordingly, the present study reported here captures the relationships between the social actions arising from the intermental dimensions of the community and, in particular, the individual cognition, emotion, and action-embodiment aspects.

Some Summative Thoughts on Embodied Cognition

In this chapter, we recognize that cognitive, emotive, and social dimensions are intertwined and it is in our attempts to explain each dimension that we have – in the preceding section – temporarily unpacked each dimension to understand the respective interrelations. Portes (1998) has used the term "social glue" to describe the process of building social relationships though trust and confidence between persons in a community. Such social glue bridges individual thought and action thereby increasing an athlete's confidence in embodied-action. There is "glue" when individuals learn of similar tensions and struggles that are experienced.

Mediations for individual and social levels involve thought, motion, and embodied action. These three aspects are inseparable in effective learning. In the learning process, meanings are appropriated through such mediations. Externally mediated artifacts are worked upon and through cognitive and embodied regulation become internal – both in terms of mind and body.

Inter- and intra-levels of cognition and embodiment remain inseparable. John-Steiner (2000) has discussed the role of affect between interactants within a ZPD. We reiterate that the transition from scientific concepts to spontaneous concepts is a dialectical process which depends on many factors – from social and cultural-level supports and structures, to individual adaptation, motivations, and perseverance influenced by others at the intermental and intercorporeal levels. Individual motivations and confidence cannot be decontextualized but dialectically arise from competencies developed through discipline, hardwork, and (socio-) cognition and learning. Emotion and thought are a dialectical embodiment when appropriated, and, when iterated in performance, become both an aesthetic and kinaesthetic experience.

Embodied Cognition at the Level of the Individual

In the case study, recordings of the performance-in-action of the student were used as a mediational tool between what he was taught and how he performed when he was on his own. We argue that such recordings are a socially mediated artifact as he was observing himself, learning from the observation and generating inferences beyond the observation.

In the process of learning to make hypotheses one's own, one has to undergo "ups and downs," testing hypotheses against one's own embodied actions with the

precision needed to perform that role or function (Barron 2006). One's mediating artifact is the feedback one receives from one's experience. This feedback can be, for example, the situated response of a coach or simply feedback from the consequences of the experimentation. What is subtle is the feeling of fluency in the experience of performance. When one has had many trials in experimentation, one feels it in an embodied sense, whether the execution was done well or otherwise. For bowlers, this feeling comes almost immediately after the ball leaves their hand. A bowler need not wait till the ball hits the pins.

We argue that this corporeal "feeling," for example having confidence or frustration, is a legitimate artifact mediating thought and action-performance. Work on neuroscience shows that emotions and movements are intimately related (e.g., Ratey 2001). Emotional impulses go directly to the amygdala and insula cortex, which trigger actions in the motor system. In knowledge management literature (Nonaka and von Krogh 2009), tacit knowledge does not discuss emotions as part of interpersonal abilities. In the context of bowling, bowlers are encouraged to respond based on experience. However, after competition, reflection and dialogue are mediational means to improve upon subsequent attempts. In competitions, bowlers need to respond and make judgments based on their intuitions. We argue that the experience in the form of corporeal response is the mediational construct. The performance shows skill in action. The mediation is largely intuition based on past-performed experiences in play. For experienced athletes, especially during competition, performance is intuitive.

Embodied Cognition at the Level of the Social

This chapter has suggested how learning occurs at both the social and individual levels. Human beings live in cultural webs, making and remaking our environments. Every tool and artifact has its own history (Petroski 1994). This cultural environment influences human cognition, emotion, responses, and vice versa. Vygotsky (1978) viewed one of the influences on human responses as active adaptation, in which humans actively adapt the environment to suit themselves.

Active adaptation can be characterized by two phases. In the first phase, the learner experiences culturally established norms and practices from others and responds to the situated environment using tools available to him to assimilate and adapt the explicit and scientifically established concepts to his intuitive and tacit understandings. Both established knowledge and tacit understandings are in dialectic relationship.

In the second phase, the learner (using the same tools) executes higher-order mental functions. An example is speech, which originally is a communication tool with others and later, as a tool for inner speech, becomes a means of thinking (Vygotsky 1966, p. 40). By learning scientific concepts, a child can easily redefine them into concepts, apply them in various logical operations, and identify relations between them and other concepts (Vygotsky 1962, p. 218). The formal discipline of

established concepts gradually transforms the structure of the child's intuitive understandings and helps organize them into a system: this furthers the child's ascent to higher developmental levels (Vygotsky 1986, p. 206).

Concomitantly, Nonaka's and von Krogh's (2009) framing of tacit and explicit knowledge is also aligned with Vygotsky. They view that the development of tacit and explicit knowledge is explained largely as a social process; little attention has been paid to the individual appropriation from the intermental level into the tacit-intuitive knowledge of the individual. In other words, the dimensions of corporeal actions and emotions tend to be overshadowed by the social aspects of learning.

The recent phenomenon of the Arab Spring can be considered as an example of intercorporeality. The mediational means – online forums – made views overt and fueled the collective intercorporeality of large crowds taking to the streets. This is a vivid explication of many voices in online discussions and the perceptions of social others who hold similar views.

The consolidated representation of views has a powerful effect on individual cognition, emotion, and action. In recognizing these influences on learning, schools have initiated structures with communities to engage learners in inter- and intramental and intercorporeal experiences and not limit learning to classroom activities. For instance, joint timetables that integrate out-of-school activities by communities with schools' formal curriculum are common in Singapore's specialized schools. We have observed that these trends are also emerging in mainstream schools.

In this chapter, we have framed a theory of learning that interconnects thought, emotion, and action. We recognize that Vygotsky centered his theory on the origins of thought and how the latter relates to language. We have explored how thought is not just linked to language but also influenced by the body.

An embodied perspective is critical to the Disciplinary Intuitions approach because of how we understand intuitions; we see the latter as innate modules of mind – which by themselves are rudimentary and are exercised and developed (only) if and when the individual utilizes them as he or she interacts with his or her (physical – including "virtual" – and/or social) environment. We appropriate the mediation metaphor and suggest that thought is also mediated by corporeal action and emotion. We hope to have suggested the significance of embodiment in this social learning process. While we acknowledge that our singular case study as represented in this chapter cannot be generalizable, we hope it has helped to advance a dialogue into this important work.

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Chapter 2
On the Nature of Disciplinary Intuitions

Michael Tan and Kenneth Y.T. Lim

Opening Thoughts on Intuition and Disciplinarity

What is the nature of intuition? Quite simply, in the words of Michael Polanyi as he discussed tacit knowledge, we can know more than we can tell (2009). Let us begin with some guiding questions to facilitate the reading of this chapter. We begin from an analysis of the disciplinarity of knowledge, which appears as a sociological question: What are disciplines? Do they refer to any "real" distinctions between forms of knowledge, or are they merely determined by cartels of robed academics carving out particular niches to solidify their prestige? In an age where we can all "google it," what use do we have for the stuffy old academic distinctions? From there, we zoom in to consider psychological and cognitive aspects. We will consider questions such as: How do we think, and have language? Are phenomena such as the development of language purely the result of sociality, or is there something else deeper? And then, finally to tie everything back together: What might some implications be for learning?

Polanyi points to the importance of considering the entire body as our means to probe and come to know truths about the universe in which we exist; in other words, we can have "muscle memory" of how to perform a repetitive task with a mechanical device, which can potentially inform the way we understand how the device works, but in such a way that is not expressible in formal language. Polanyi also claims that trying to formalize all forms of knowledge is probably futile (p. 20), and there will perhaps always be ineffable knowledge forms which permeate our conscious formalized knowledge and its process of acquisition.

M. Tan • K.Y.T. Lim (✉)
Centre for Research in Pedagogy and Practice,
National Institute of Education, Singapore, Singapore
e-mail: michael.tan@nie.edu.sg; kenneth.lim@nie.edu.sg

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Polanyi's insightful words were written in 1966, and we have had several grand leaps in our understanding of cognition and learning since. Significantly, we have come closer to understanding the workings of the human mind, largely facilitated by the computing and artificial intelligence revolution, especially if we see these as experiments in applied cognitive research. We have also come to an increasingly sophisticated understanding of the nature–nurture debate, where we now can respond that it is both; we also know that there ought to be innate cognitive modules primed to respond intelligently to external stimuli. Importantly, this then implies that there is some form of stable reality to which we can develop dependable knowledge, for which we may obtain a sufficiently high degree of intersubjectivity, and hence, truth. As such, the disciplinarity of knowledge can (and should) be defended.

Sociological Arguments for Disciplinarity

Mark Taylor, in his *New York Times* op-ed (2009), claims, boldly, that we should "end the university as we know it"—one of his reasons being that the disciplinary boundaries currently in universities are unhelpful for contemporary problems, which are often multi- and transdisciplinary, and for which university academics cannot go very much beyond their specific areas of specialization to arrive at satisfactory solutions:

> The division-of-labor model of separate departments is obsolete and must be replaced with a curriculum structured like a web or complex adaptive network. Responsible teaching and scholarship must become *cross-disciplinary and cross-cultural*. (emphasis added)

But these notions of disciplinarity are certainly not novel, and calls for greater interdisciplinarity have had a history of almost a century now (Applebee et al. 2007). Disciplinary boundaries have been imagined to be artificial, a form of preservation of institutional privilege unjustly earned, and even likened to a straitjacket for the free exchange and flow of ideas. In order to better understand the nature of disciplinary boundaries, it is helpful to begin an enquiry from a sociological position, considering the role of disciplinary boundaries as they play out in the organization and production of truth claims, before next considering ontological and epistemological aspects of knowledge, and what recent thought about the nature of knowledge and truth may imply for learning and the disciplinary organization of knowledge.

When C.P. Snow presented the Rede lecture at Cambridge in 1959, he described two cultures of intellectual communities, namely the sciences and the humanities, each with their divergent interests, research agenda, and mutual incomprehension bordering on hostility and dislike:

> The non-scientists have a rooted impression that the scientists are shallowly optimistic, unaware of man's condition. On the other hand, the scientists believe that the literary

> intellectuals are totally lacking in foresight, peculiarly unconcerned with their brother men, in a deep sense anti-intellectual, anxious to restrict both art and thought to the existential moment. (p. 5)

The existence of this gulf had implications for the way that society's problems were to be addressed, especially if consilience were not to be reached, and learners could not benefit from being able to see past differences. Having drawn the divisions, a natural question that came to occupy the academic interest was the idea of demarcation—what is it that makes science *science,* and how might one distinguish science from nonscience. One of the dominant responses came from Karl Popper (1959), whose idea of a test for science was that of falsifiability: a theory could be properly considered scientific if it could be falsified. For instance, the claim that all swans were white could be proven false if a single black swan could be identified.

Eventually though, falsifiability was found to be insufficient—there are no clear-cut means for deciding how something might come to be judged to be impossible to falsify (Feyerabend 1993). Falsifiability as a criterion was recognized as merely a mechanism for deferring the question of judging; in other words, the criterion for boundary demarcation was to be located elsewhere. It was the next move in the demarcation problem that led eventually to a greater public awareness of epistemological issues: How is it that we know what we know?

Thomas Kuhn (1962), in *The Structure of Scientific Revolutions* argued that scientific knowledge did not accrete in a linear fashion, but rather, there were periods of relative stability in knowledge production, while errors, inconsistencies, and the inability of the extant theory to explain phenomena became increasingly apparent. At one point, a rival theory is proposed, forming a new explanatory paradigm incommensurable to the older theory. Important to these ideas proposed, however, was Kuhn's suggestion that there were social factors that influenced the reception or otherwise of new theories. That is, in opposition to the logical positivist position that correspondence to empirical reality was the only means for assessing the veracity of truth claims, Kuhn was interpreted by many to mean that scientists' personalities, institutional reputations, and such subjective qualities as "elegance" of the theory were often more important than mere improved correspondence. Kuhn's work opened up the new field of sociological studies of scientific knowledge, seeking to find evidence for sociological means of legitimizing truth claims in scientific practice.

The problem became one of identifying nonempirical factors for the acceptance or otherwise of truth claims. Several noted contributors included Bruno Latour (1993), Sandra Harding (1991), and Luce Irigaray. Latour studied the acceptance of Pasteur's ideas on the discovery of the microbe as disease-causing agents, highlighting the uneven manner in which his ideas were accepted, and the differences in the social contexts which aided or hindered the acceptance of his theories. Harding and Irigaray have offered their respective feminist critiques. It follows that at least on a sociological level, there are adequate reasons to support a disciplinary organization of knowledge. However, the epistemological problem

we posed earlier has not been adequately addressed: Do knowledge boundaries actually cohere to anything "out there" in reality? Does it necessarily follow that just because something works sociologically, its underlying epistemic reasoning is sound?

Building an Epistemological Case for Disciplinarity

As a quick depiction of the polar extremes of the epistemological argument which influence disciplinarity: on the one pole, a logical positivist position holds that truth is only possible when there is correspondence between the claim and empirical reality, and on the other, that truth claims are made in relation to one's position in social existence; and associated with this latter pole, an extreme skepticism of the existence, or even possibility, of truth. With the latter pole, all we have, as the postmodernists and social constructionists insist, is discourse, and power relations to determine who speaks the truth.

Social realism, the philosophy that one of the leaders of the New Sociology of Education movement—Michael F.D. Young (1971, 2008)—came to champion, can be thought of as occupying a middle position between positivism and social constructivism. Among its educational implications is that knowledge structures exist, and are not arbitrary, but instead refer to a structured reality that behaves in uniform ways and provides reliable means for adjudicating truth claims. The latter are mediated by social interactions, but in part because we have surprisingly similar mental and sensory systems, these social mechanisms for arriving at truth are not, for the most part, up to the whims of self-interested individuals; through social mechanisms like competitive cross-validation, better approximations to reality can be approached. And because these mechanisms for reducing bias and enhancing correspondence to truth exist within particular stocks of knowledge, and are often domain-specific, it is important that disciplinary structures persist, not just as warehouses of our best available knowledge, but also as demonstrative exemplars of how these social mechanisms are to applied to new and unforeseeable situations that learners may eventually encounter.

For instance, if we were to consider the truth claims of a scientist working at the European Organisation for Nuclear Research—CERN, we may decide to trust the newspaper journalist, who trusted the scientist informant, who trusted the Principal Investigator at CERN, who trusted his research collaborators, who trusted his assistants, who trusted their technicians, who trusted the manufacturers of precision tools and other equipment, … and so on. All along this chain of trust exists numerous possibilities for the violation of trust, but, crucially, there are ways to discern such violations, we are able to tell, sooner or later, where these violations occurred, and what the more accurate versions of truth are. It is this corroboration with reality that is really the key principle here, and the reason why we can insist on the Disciplinarity of Intuitions—there really are objects in nature to which things refer to, and the distinction between the physics approach to a particular problem as opposed to a sociological one, is real and not arbitrary.

The Nature of Knowledge

The problem of philosophical skepticism is an old one, and one that has generated an entire field of epistemology (Williams 2001). The foundational problem here is how we can have knowledge, and how do we distinguish between knowledge—which we may recast as justified true beliefs—and "mere" opinion? It appears that we have not gotten very far from the Agrippan formulation of the problem; Agrippa, the ancient Greek skeptic, proposed that we only have three recourses for justification: infinite regress, circularity, and assumption. The infinite regress is the rhetorical move encountered by parents of young children who discover, for the first time, the recursive property of the magical word: "Why?" With circularity, justifications proceed until some point where one repeats what was previously mentioned; and with assumption, one refuses the infinite regress by reference to a claim that is dogmatically assumed. Williams (ibid.) argues that if the infinite regress is to be considered intolerable, we are left with either of circularity or assumption as archetypal forms of justification. These two approaches, suitably expanded, become coherentism and foundationalism respectively, and help us understand the problem of disciplinary boundaries.

Put in these terms, for adherents of coherentism, what matters is the holistic coherence and consistency of the overall set of claims that make up the "package" of claims, even though the possibility exists that the set of claims may be entirely coherent yet entirely untrue. Coherentism largely underwrites postmodern thought; researchers surveyed earlier (Barrett 2012; Maton and Christie 2011; Wheelahan 2010) have pointed out the inadequacies thereof, especially for a theory of learning.

As for foundationalists, what matters is the location of basis claims—the self-evidentially true statements that one may use to build further truth claims, even though there is significant skepticism on the possibility of finding such claims. Seen in this light, positivism is a special case of foundationalism in that positivists claim that these self-evidentially true claims must arise from a correspondence to empirical data.

Running counter to these Agrippan forms of skepticism is Cartesian skepticism. Adherents to the latter argue against the possibility that science is in any way special (and hence would more likely advocate a dismantling of disciplinary boundaries). It did the sciences and the "traditional" disciplinary boundaries no favors to note that science and technology brought about expanded ways for humans to hate and oppress one another and bespoil the environment—if such horrors could visit the human condition due to these knowledges, there must be something inherently wrong with them. And if the boundary between science and other knowledges could be weakened, why not remove *all* "artificial" barriers to free and open interchange of ideas? The position of the contributing authors of this book would be that we do not need infallible knowledge of the world, just knowledge sufficiently reliable for our purposes. We do not need to know *for certain* that we will never find the black swan [that proves wrong the assertion that all swans are white].

To be certain, the situation is more nuanced than we present, and foundationalism is not perfect—the problem of the basis (upon which claims are built) is one that is not easily resolved. That being said, going forward we wish to choose from the Agrippan form of skepticism the mode of assumption and its associated philosophy of foundationalism in order to develop Disciplinary Intuitions.

The position we have just described corresponds to that of critical social realism (see, e.g., Moore 2007, 2009). To repeat, social realism may be described as a hybrid position: ontologically foundationalist, while epistemologically coherentist. The claim is that there exists an independent reality to which truth claims may be corroborated to, but at the same time, because we are social creatures and because our contemporary efforts to arrive at truth claims is dependent to a large extent on social organization, we often rely on social norms for assessing the veracity of truth claims. This is not to discount the numerous advances that postmodernist philosophy has provided to the intellectual discussion: for one, with increasing sociality comes the problem of political affiliation and the effect of political organizations in influencing the apparent veracity of truth claims. Nonetheless, the position we take here is that the glass is actually half full, understanding that deceit is always possible, but choosing optimism anyway.

On Intuition: How Our Senses Deceive Us, and Why This Is Actually a Good Thing

With Cartesian skepticism, we had the problem of knowledge about the external world—how is it we can come to know about it. There are very real reasons why we might want to be concerned about the degree of security we possess over our knowledge of the world. For instance, we live in a world of human proportions—we see light at a very narrow range of the electromagnetic spectrum; we are human-sized, neither atom-sized nor the size of galaxies; have limited life spans in the order of about a hundred years, neither microseconds nor millenia. What this means is that we cannot have perfect knowledge; our knowledge remains tentative and limited, and there are inferential chains that we must tolerate in order to have even workable knowledge about such phenomena as black holes, plate tectonics, abiogenesis, and the nature of our known universe. Here, it is probably wise to start asking: Do these human-scale senses possess any particular affordances which incapacitate us in particular ways? Or, as the section title suggests: Do our senses deceive us?

Because we derive so much of our information about the world through our visual sense, it is useful here to discuss an example of how this sense can be easily fooled, and what this might mean for us. Consider the following example, which depicts two views of the same learning installation conceptualized by an Art teacher in a state-funded school in Singapore, and built within a three-dimensional immersive environment by Derek Chua (a member of Lim's (2009) team). The illustrations show how—from one perspective—a given scene looks "right," while—from another perspective—it can look quite puzzling (Fig. 2.1).

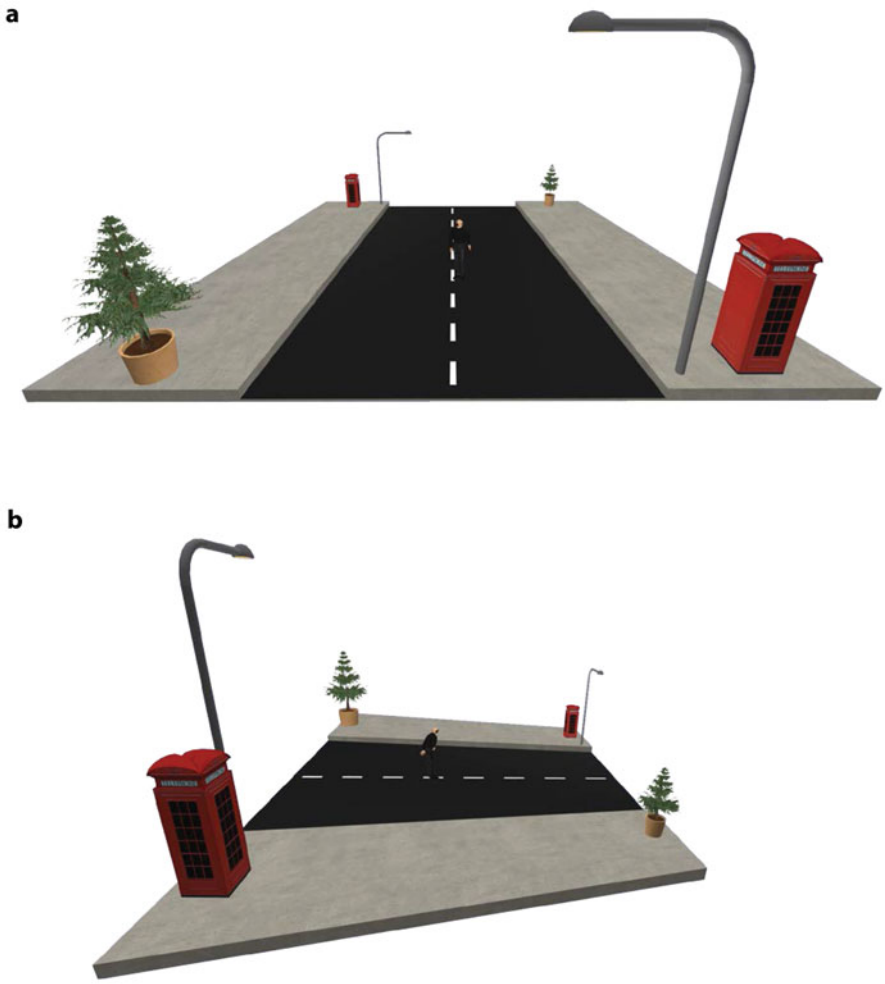

Fig. 2.1 (**a**) A street-scene in an immersive environment. (**b**) The same scene, from a different perspective

This illusion "works" because of our general familiarity with streets and urban landscapes. Illusions like these are especially convincing to claims that we cannot trust our senses; and, if relativists are correct, that truth claims are truly relative to the contexts under which these claims are made.

However, there is more to this example than meets the eye (pun intended), and this example actually leads us to our understanding of the concept of intuitions. More to the point, this example leads us to think about the mental processing required for vision; or more generally, as Pinker (1997) points out as the core problem that cognitive science and artificial intelligence researchers have struggled with for decades: What are the kinds of challenges in designing/programming a robot

that can match the abilities of a human being? The ambition here is with *understanding*; to be able to explain how it is that our minds work.

When the problem is analyzed, the problem of vision is understood to be hard indeed. Even something that we take for granted as the ability to distinguish different objects as distinct is a considerable challenge, let alone other fascinating things we can do such as recognize faces. In object detection, there needs to be an algorithm to detect edges, and this information needs to be combined with another algorithm to detect depth through binocular vision, and yet another algorithm that detects shading as all these information provides cues to the spatial location of objects. How does the human mind do these kinds of processing? From a computational and information processing perspective, it must be clear that if we can study the informational tasks needed, a highly similar, if not identical informational flow needs to happen within the mind. The terminology here needs to be careful: at this point of the discussion, we will use the word "mind," not "brain" because the interest is in function, not anatomy. Similar to how the circulatory system is a function in which the heart plays a major part, we will not be concerned *how* the computation actually happens, but instead be interested in what the mind needs to do in order to perform the feats that it does.

The claim here is that we are able, through logical argumentation and observation of basic phenomena, to understand how our own mental functioning works—called the computational theory of mind:

> The key idea is that the answer to the question "What makes a system smart?" is not the kind of stuff it is made of or the kind of energy flowing through it, but what the parts of the machine stand for and how the patterns of changes inside it are designed to mirror truth-preserving relationships (including probabilistic and fuzzy truths). (Pinker 1997, p. 77)

The investigations and analyses of the computational theory of mind have much to inform educational studies. For our purposes here, there are two important considerations of this line of work. First, almost with echoes of nineteenth-century Taylorism, when we consider mental processes, as suggested earlier, we come to the general conclusion that there ought to be specialized mental "machinery" or structures (loosely) which deal exclusively with very specific tasks, with combinatoric assembly of these subroutines as responsible for the construction of the general intelligence that we take for granted and struggle to explain in noncircular means. Second, there appears to be evidence for a certain innateness and commonality of these mechanisms across the human species.

The Disciplinarity in Intuitions: Innate Abilities of the Mind

The evidence sources for these claims are as astounding as the claims themselves. For instance, take the case of one Phineas Gage, the railroad worker who, in an unfortunate incident while he was tamping explosives into a hole, had the tamping rod blasted through his head, from under his cheekbone and out through the top of his skull. Phineas survived the incident, and while Phineas was a pleasant,

hardworking, ambitious person before the incident, he became rude, unreliable and shiftless, even though his other mental functions were intact. His ventromedial prefrontal cortex was destroyed, a region "of the brain above the eyes now known to be involved in reasoning about other people. Together with other areas of the prefrontal lobes and the limbic system (the seat of the emotions), it anticipates the consequences of one's actions and selects behavior consonant with one's goals" (Pinker 2002). This case, a classic in psychology textbooks, tell us quite clearly that there are various parts of the brain involved in various segments of our cognition, and that in numerous cases of individuals who have selective damage (either by disease, accident, or congenital reasons) to different parts of the brain, different aspects of cognition are selectively lost.

Or take the case of "Mr. M," studied by Laurent Cohen and Stanislas Dehaene (in Lakoff and Núñez 2000). Mr. M had the curious disability to tell the number between say 3 and 5, but could correctly give names to numerals. He could not do basic arithmetic, could not perform mathematical bisection (e.g., cannot tell if 45 or 8 lies between 2 and 10). However, Mr. M has his rote arithmetic knowledge intact, he is able to recall the multiplication table. As Lakoff and Núñez surmise, "he has lost every intuition about arithmetic, but he preserves rote memory. He can perform simple rote calculations, *but he does not understand them*." (ibid., p. 24, emphasis added). Mr. M was diagnosed with lesions in the inferior parietal cortex, "located anatomically where neural connections from vision, audition, and touch come together—a location appropriate for numerical abilities, since they are common to all sensory modalities" (ibid.). Lesions here, besides disabling patients' mathematical abilities, also generally impact patients abilities in writing, representing fingers on the hand, and distinguishing left from right, as Mr. M demonstrated. This case, again, demonstrates the specificity of the brain regions involved in particular forms of computation, and in concert with other cases, hints at the remarkable similarity of brain function across different individuals, generalizable across our entire species.

It is from evidence such as the preceding two examples that we begin to appreciate there appear to be mental structures that are innate to the human species which carry out specific tasks, in very predictable ways.

A prime example, again from the domain of mathematics, is the idea of subitizing. Subitizing is the innate ability to tell, at a glance, the number of items in a collection, and forms the foundation for such feats as efficient usage of the abacus and the ability to identify instantly numbers on dice and playing cards. Studies in the Violation of Expectations in babies as young as 4.5 months have permitted their subitizing ability to be inferred by studying fixation time: the duration which they stare at a pattern of dots. For example, a pattern of two dots is presented to a baby; she soon gets familiarized with this pattern and starts to ignore it. Without prior notice or other cues, this pattern is suddenly changed to one with three dots. Immediately the baby exhibits a longer fixation time with this new pattern, indicating that she could tell the difference between the number of dots. A fuller review may be found in Mandler and Shebo (1982).

If subitizing is deemed fairly straightforward, studies that showed infant abilities to add and subtract, or, more precisely, discern addition and subtraction, are nothing

short of remarkable. In one study (Wynn 1992), investigators placed an object within a field of view of the infant, obscured this object with a screen, visibly added an additional object behind the screen, then visibly withdrew an empty hand. When the screen was lowered, two possible scenarios were presented to the children: either two objects were revealed, or one. Measuring fixation times again, investigators found that infants stared longer when an incongruous result (one or three items) was presented. Again, with similar inference pattern, the innate ability of some animals has been determined (Lakoff and Núñez 2000).

Our mathematical abilities appear to be innate. To understand how we can come to understand abstract concepts, Lakoff and Núñez (ibid.) contend that we make use of conceptual metaphors; these can be thought of as a system of *inference-preserving* mappings from one conceptual domain into another. These conceptual metaphors allow us, for example, to connect operations valid for groups of objects into the principles of arithmetic operations, or conflate our experiences of traveling along defined paths to the rules for the manipulation of negative numbers, in the process preserving the rules valid for one domain into another more abstract one.[1]

While discussing metaphors, it is also appropriate here to point out studies in linguistics: numerous studies have shown remarkable similarities across the different languages in use throughout the world, not in the representational form used but in the grammatical structure; this is elaborated upon in Chapter 8. Chomsky's Universal Grammar posits the innate ability of the human mind to acquire linguistic ability, and interrelatedly imply that there are grammatical properties that are common to human languages, which hint at both the regularity of the reality that confronts our senses and, more significantly, the uniformity of the human computational mechanisms required to process language. In the words of Pinker (1997):

> […] it is a significant discovery that both [Japanese and English] languages have verbs, objects, and pre- or postpositions to start with, as opposed to having the countless other conceivable kinds of apparatus that could power a communication system. And it is even more significant that unrelated languages build their phrases by assembling a head (such as a verb or preposition) and a complement (such as a noun phrase) and assigning a consistent order to the two.

The standard objections to such innate theories of mind lie in the idea that the mind should remain inexplicable through mechanistic means. One might fear a mechanistic erosion of the concept of free will. We bookmark this and acknowledge that we are aware of this challenge. Ways forward exist in various forms; a leading contender being that of complexity theory whose fundamental insight is that simple mechanisms can give rise to highly unpredictable results at larger scales of interactions because of the simple laws of combinatorics and huge numbers.

When we consider the weight of the evidence, noticing similarities across the various cultures and especially when we take a "top-down reverse engineering approach" (Dennett 1998) to logically analyzing how "intelligence" may arise from

[1] For example, 1 object added to another gives 2 :: $1+1=2$.

computational structures of flesh, we come to the conclusion that at least at some minimal level, there exists some degree of innateness in the numerous talents that human beings may display. The number of innate talents and the means by which these are developed are not well-known; Pinker points to about ten innate cognitive faculties that cognitive scientists have been able to identify. These include intuitive physics and intuitive biology (developed in Chapter 5), intuitive engineering (developed in Chapter 6), spatial sense (developed in Chapter 7), language (developed in Chapters 8, 9 and 10), and number sense (developed in Chapter 11). The remaining faculties have been identified as (1) intuitive psychology, (2) probabilistic sense, (3) intuitive economics, and (4) mental database and logic.

The natural question that arises from such observations of innateness would be to ask: Where do these innate modules come from? This question may be answered in two parts. First, these innate faculties appear to be essential for the optimal "operation" of the human organism; for example, our spatial sense prevented our ancestors from flinging themselves off cliffs, their relatives which were not able to instinctually differentiate between "prospect," "refuge," and "hazard" (Appleton 1975) would not have been around to be our ancestors. Intuitive biology would be necessary for the species to understand disease-causing agents and to avoid bodily discharges; intuitive number sense allows us to tell, at a glance, whether there was only one predator, or three, and therefore select the appropriate response.

The second explanation of how we acquire these intuitions is more interesting: it appears that the information contained in the human genome is not enough to uniquely specify all aspects of the human organism. For example, the curvature of the lens in the human eye, and the exact location within the brain of the various computing circuits dedicated to the various senses, in relation to other regions, cannot be contained with the informational content of the human genome. How then, can we develop such concepts as intuitive psychology? The solution that was discovered, spawning its own field of research called epigenetics, was that the immediate environment that the cells were in played a vitally important role in the correct expression of the appropriate segment of the gene. Through a process of feedback loops, such interactions with the environment ensures that the appropriate cell, organ, or system develops in the correct location and is "wired up" (especially in the brain) to its correct partner. For example, Pinker points out that the following specifications appear to be dependent on such environmental interactions: the distance between the lens in the eye and the retina; the curvature of the hip ball and socket joint; and the neural wiring in the brain. In the case of the hip ball and socket joint, this joint requires that the developing embryo rotate the joint through its normal range of motions; in experimental embryos where the joint is paralyzed, the joint develops into a badly misshapen form. There is reason, then, to believe that our innate mental faculties develop as a result of similar kind of environmental feedback; as infants develop, manipulating objects develops the intuitive physical sense, interactions with other children in give-and-take develops their intuitive economics, and so on.

Disciplinary Intuitions

There should now be a fairly clear indication of where we situate Disciplinary Intuitions. In the first two chapters of this book, we have been accreting evidence for the embodied or grounded nature of cognitive processes. The grounded/embodied perspective extends beyond the brain per se when considering cognition. As an example, children are often taught basic arithmetic by reference to their fingers as counting objects; these processes involve corporeal manipulation as essential to cognition. Our understanding of mathematics – the "language of science" – can be thought of as a metaphorical extension of corporeal experiences and processes (Lakoff and Núñez 2000).

Similarly, in terms of processing language, emotions, beliefs, and our state of consciousness, our cognitive processes need to be thought of as being reliant on the external environment. Our understanding of language metaphors is grounded in schema derived from our day-to-day experiences of a manifest reality (Lakoff 1987). For instance, when subjects were asked to read a sentence "the ranger saw the eagle in the sky," and presented pictures of either an eagle with wings outstretched or folded, subjects were faster at identifying the eagle with outstretched wings (Zwann and Madden 2005; in Barsalou 2008; see also, Hall and Nemirovsky 2012; Wilson 2002). In other research summarized by Barsalou (2008), participants' motor systems became active by simply reading out action-words; motor simulations triggered by words produced priming across lexical decision trials; and when reading about a sport – such as bowling (as elaborated upon in the preceding chapter) – experts were found to produce motor simulations absent in novices. A similar set of results have been summarized by Bergen and Feldman (2008): numerous empirical findings show that cognitive simulations are the basis for comprehension and processing of language and abstract thought. Rowlands (2010), for example, even posits that corporeal and object configurations are not to be thought of as representations of cognitive states (like fingers in counting), but rather that these are cognitive processes in themselves.

If the configurations and interaction with objects outside the body are instrumental to cognition, then what about social interactions with other minds? In the preceding chapter, we considered the use of language, which must now be reconsidered as a form of externalizing cognition:

> Without language, we might be much more akin to discrete Cartesian "inner" minds, in which high-level cognition relies largely on internal resources. But the advent of language has allowed us to spread this burden into the world. Language, thus construed, is not a mirror of our inner states but a complement to them. It serves as a tool whose role is to extend cognition in ways that on-board devices cannot. Indeed, it may be that the intellectual explosion in recent evolutionary time is due as much to this linguistically-enabled extension of cognition as to any independent development in our inner cognitive resources. (Clark and Chalmers 1998)

By way of drawing this chapter to a close, we refer to Intuition as innateness in the epigenetics-inspired sense that innate beliefs/understandings/instincts

are crucially dependent on interactions between the developing the individual and its environment. As for Disciplinarity, we have explored epistemology in order to establish the nature of knowledge and knowledge boundaries. This was because in order to understand the nature of knowledge and of categories, we not only had to gain insight into reality and its representation, but also to acquire knowledge about the self, about how it is that we can even know, or, even more generally, how is it that we are conscious enough to know. Through this process of coming to know our computational machinery, we close the loop with the concept of innate modular computational elements. These modules have their form in response to the regularity of reality.

These innate cognitive modularities are our current best attempt at explanation of the nature of the human mind. If the external environment constitutes resources for cognition, and there exist innate cognitive modules primed to develop intuitive understandings of the way the world behaves, we respectfully suggest that educators seek to design learning activities and environments in order to develop and surface these otherwise tacit intuitions.

This is because these innate modules are very rudimentary, and if opportunities do not arise for them to be developed, they provide only foundational support for learning to occur. As Pinker (1997) points out:

> Conspicuous by their absence are faculties suited to the stunning new understanding of the world wrought by science and technology. For many domains of knowledge, the mind could not have evolved dedicated machinery, the brain and genome show no hints of specialization, and people show no spontaneous intuitive understanding either in the crib or afterward. They include modern physics, cosmology, genetics, evolution, neuroscience, embryology, economics, and mathematics.
>
> It's not just that we have to go to school or read books to learn these subjects. It's that we have no mental tools to grasp them intuitively. We depend on analogies that press an old mental faculty into service, or on jerry-built mental contraptions that wire together bits and pieces of other faculties. Understanding in these domains is likely to be uneven, shallow, and contaminated by primitive intuitions. And that can shape debates in the border disputes in which science and technology make contact with everyday life.

Education is interested in students' learning of these nonintuitive, noninnate knowledge forms. For example, for normally functioning children, the spoken language, an innate capacity, is far more easily acquired than the ability to read and write.

Thus informed by recent advances in the cognitive sciences, we consider Disciplinary Intuitions to be innate computational modules of mind which are in the process of being exercised and developed as the learner interacts with his or her external environment.

Given this definition, Disciplinary Intuitions has its roots in embodied cognition, social realism, and the computational theory of mind.

An embodied perspective is critical to the Disciplinary Intuitions approach because of how we understand intuitions; we see the latter as innate modules of mind – which by themselves are rudimentary and are exercised and developed (only) if and when the individual utilizes them as he or she interacts with his or her (physical (including "virtual") and/or social) environment.

In turn, the social realist perspective is equally critical to the Disciplinary Intuitions approach because it provides an epistemological (and sociological) ground from which to argue for a disciplinary structuring of "reality" – the same disciplinarity thereof is mirrored in the typology of the innate modules of mind described in the computational theory of mind.

From the perspective of Disciplinary Intuitions, the challenge is then to design pedagogical approaches which would foster these innate capacities: for example, if the whole-language approach is understood as leaning toward an "innate" assumption of language acquisition, and the phonics approach treats language as a skill that can be acquired, Disciplinary Intuitions looks to providing principled means for deciding when it would be appropriate to use one of either method, or some combination thereof.

We have come to the conclusion that there are innate cognitive modules which are dependent on their interactions with the environment to be more developed. We also draw from the computational theory of mind, from which we gain insight into the workings of the mind. The second major insight is the disciplinary nature of our underlying reality. The major goal of this chapter then is the advocacy of more reality-based experimentation and "messing about" (Ito et al. 2013) with things, not necessarily in any directed way, in order to develop better and more nuanced ways of understanding the reality of things, and also to develop a deeper appreciation of the theoretical knowledge of the disciplines.

From the perspective of embodied cognition, it is incumbent on curriculum designers to design learning environments that cater to more than just the traditional media of communication of sight and sound. For example, while practical investigations are already part of science curricula, there is a sense in which the scriptedness that often typifies such structured investigations misses out on an essential aspect of learning. We have to get messy and deal with interpersonal relations as learners negotiate the social. This is especially so given the diversity of backgrounds from which learners come. Learners' prior experiences with physical phenomena need to be carefully attended to, and carefully designed so that intuitions are surfaced and developed.

In summary, the central problem that Disciplinary Intuitions addresses is the acquisition of our culturally derived modern forms of knowledge in relation to the innate capacities of the human mind: What is the role of interactions between the environment and the individual in learning? This chapter has sought to provide the underlying theoretical basis for an approach to designing for learning, which we will develop and exemplify in the rest of the book.

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Chapter 3
Learning Through Intuition in Early China

Ming De Yuen

Education in Classical Chinese Philosophy

In this chapter, I offer a few generalizations about early classical Chinese views of education and then propose some general principles that underline the methods and practices of the classical Chinese teachers with respect to the tapping of the intuitive understandings of their disciples.

There are two general ways of looking at learning – a traditional, absorbed, and retained view of learning in which the teacher's role is to "dispense" information to the student. The material is somehow taken in and absorbed by the learner and retained in the same form it is encountered. Learning is efficient if the learner has absorbed the material and is able to represent it reasonably close to the form in which it was presented. The constructive view, on the other hand, focuses on the activities of the learner in making sense of the world or meanings in their experiences. Learning becomes the development of a vast and flexible network of ideas and feelings with groups of more tightly associated linked ideas (Moon 2004, p. 16).

A dominant feature of the education system and social structure in East Asian societies is the practice of private tutoring arrangement or cram school – "'juku' in Japan, "buxiban" in Taiwan, "hagwon" in Korea, "tutorial school" in Hong Kong," and so on (Kennedy and Lee 2007, p. 74) – the aim of which is to prepare students to score well on standardized tests in high-stakes national examinations (Kim and Park 2010). Historically, the first public written examination system was introduced in China as a merit-based approach for appointments to government office. In theory, people of humble birth could rise to the upper class by their own will and effort, and those who wished to attain political office often spent years on memorization of a set of classics. This gives rise to an incomplete picture that historically, the Chinese

M.D. Yuen (✉)
Office of Education Research, National Institute of Education, Singapore, Singapore
e-mail: mingde.yuen@nie.edu.sg

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focus on education is based on the rote learning required by the rigid exam system, with little regard for individual inquiry and holistic understanding. I would like to examine several references in classical Chinese thought that suggest that classical Chinese educators had a model of learning that cast learners as active participants in their learning, acknowledged their prior learning as foundational to current learning as opposed to abstract learning, and focused on real-world challenges and activities.

The Warring States Period of Early China (fifth to third century BCE), with its many thinkers and vibrant debates, is often seen as the classical or formative period of Chinese philosophy. These classical thinkers focus overwhelmingly on the practical issue of education. For these thinkers, the object of critical enquiry is "What is the Way?" That is, the best way to order the state and conduct personal life. In other words, their main concern is ethical in that it concerns how one should live. Different conceptions of the ethical ideal are put forward, and they are all rooted in practical concerns such as how to best restore social orders and to conduct oneself in the troubled and dangerous times (Shun 1997, pp. 1–2). These are the views we associate with such thinkers (retrospectively identified) as the Confucians, Daoists, Mohist, and so on.

The concept of education plays a prominent role in all of the texts of the period. References to *xue* (学) (study), *xiu* (修) (practice), *xi* (习) (rehearsing), *jiao* (教) (teaching), and *hua* (化) (transformation) are common. One of the earliest philosophers who set the stage for discussion and debate for centuries to come is Confucius (551 BCE to 479 BCE). He was especially vocal on the importance of education. In a collection of his sayings and teachings known as the *Lunyu* or *Analects*, there are numerous quotes on the importance of education and learning:

> The Master said, 'In a hamlet of ten households, there are bound to be those who are my equal in doing their best for others and being trustworthy in what they say, but they are unlikely to be as eager to learn as I am.' (*Analects* 5:28)[1]

> The Master said, 'I once spent all day thinking without taking food and all night thinking without going to bed, but I found that I gained nothing therefrom. It would have been better for me to have spent the time in learning.' (*Analects* 15:31)

While he was an educated person, Confucius never held high office. His aspiration was to contribute to the reform of society as he knew it, this meant being employed by a ruler and having the opportunity to translate his ideas into action. Confucius was a dedicated teacher for most of his life, while he traveled to various kingdoms to attract pupils and to find an audience for his methods and ideas. He had always presented himself as an ordinary teacher of classical texts and ceremony, a preserver and restorer of a declining culture; perhaps a particularly inspiring one, who hopes that his students could put in place the reforms that he could not.

School systems today can be said to be dominated by a service-economy model of education, in which schools are expected to train their students for successful

[1] All *Lunyu*/Analects quotations are from (Lau 1979). Lau uses of Wade Giles romanization are left as it is, although the rest of the chapter uses pinying romanization, which is currently more popular.

employment and contribution to the overall economy. This approach, a product of the Industrial Age, which relied on compliant factory workers and mass consumption, has become even more regimented in recent years due to an emphasis on standardized tests as a key indicator of competency and knowledge.

The emphasis on education and learning in the classical Chinese context is very different from the model we have become used to. Confucius was a teacher who was surrounded by disciples who aspired to high political office, which would allow them to reform society. Confucius' vision for reforming society was a simple and optimistic one: to cultivate moral and able learners who would enter office and become competent and ethical leaders, resulting in good governance which would bring about positive changes in society. Education in this context must be understood broadly as a process not merely of acquiring information, but of training and shaping the whole person through a series of a series of practices, instructions, and acquiring of certain knowledge. The model is more similar to the training at a military academy or an *Uchi-deshi* program (a form or martial arts apprenticeship, or lived-in disciple arrangement in Japan). This concept of education is articulated by Fraser (2006) as a transformation of an entire person:

> Education is seen as making us the people we are…the significance of education in the Chinese context is better captured by the Chinese expression jiaohua (transformation through education) or the German *Bildung* than by the English word 'education.' *Jiaohua* emphasizes that education effects a transformation, producing a person who literally experiences and responds to the world differently. Such a transformation is fundamentally a sort of enabling.

Knowing That and Knowing How

The Chinese character *zhi* (知) is often translated in the classical texts as "knowledge." Ames (2003) stressed that the classical Chinese understanding of this "knowledge" must be authenticated in action in order to qualify as true knowledge. *Zhi* in this understanding has pragmatic and performative connotation. In other words, to say that one *zhi* something – that one has knowledge of something, the knowledge must be understood as not just information, but that one is also practically efficacious in some ways. *Zhi* is not just knowledge in theory, but also in practice.

Confucius himself articulated the importance of having more than book knowledge in (*Analects* 13:5):

> The Master said, 'If a man who knows the three hundred Odes by heart fails the given administrative responsibilities and proves incapable of exercising his own initiative when sent to foreign states, then what use are the Odes to him, however many he may have learned?'

We can appreciate this distinction in the kind of knowledge, by classifying knowledge into expressed propositional knowledge ("knowing that") and operative knowledge ("knowing how"). Propositional knowledge includes what we can state

as a fact or what we can articulate, including for example our knowledge of how a ball travels through the air in an arc, described by a mathematical expression. Operative knowledge is knowledge that is said of you when you know how to perform something. For example, you are said to have certain operative knowledge when you run to a particular spot in a field to catch the said football.

While our propositional knowledge about the ball's parabolic trajectory might be used to inform us about where to run if we had a great deal of time and sophisticated measuring instruments, this form of knowledge is of little use in the practical circumstances of a football game. In reality, our operative knowledge of getting to the right spot is of greater relevance even though we may not be able to articulate the principles underlying this knowledge. A lot of our skills, including for example, languages, music, certain mathematics operations, riding a bicycle, and object perception, are largely categorized under forms of operative knowledge.

Any attempts to construct the form of knowledge that was sought after by the classical Chinese thinkers must acknowledge that their idea of that knowledge is a form of operative knowledge. Although it may be possible to articulate the principles behind the operative knowledge, the articulation is certainly not the operative knowledge itself. Confucius insisted that his students master practical skills needed for serving society. We can see from the aforementioned quote (13:5) that Confucius thought that memorizing texts in a pedantic way, while being unable to put the book knowledge in action, accomplishes nothing. The classical Chinese thinkers emphasized on learning and also on being able to apply what one has learned.

Engaging the Individual

Readers of the *Analects* are always struck by the fact that Confucius sometime gives contradictory instructions to his disciples. For example in *Analects* 11:22:

> *Tzu-lu* asked, 'Should one immediately put into practice what one has heard?'
>
> The Master said, 'As your father and elder brothers are still alive, you are hardly in a position immediately to put into practice what you have heard.'
>
> *Jan Yu* asked, 'Should one immediately put into practice what one has heard?'
>
> The Master said, 'Yes. One should.'
>
> *Kung-hsi Hua* said, 'When Yu (refers to *Tzu-lu*) asked whether one should immediately put into practice what one had heard, you pointed out that his father and elder brothers were alive. Yet when *Ch'iu* (refers to *Jan Yu*) asked whether one should immediately put into practice what one had heard, you answered that one should. I am puzzled. May I be enlightened?'
>
> The Master said, '*Ch'iu* holds himself back. It is for this reason that I tried to urge him on. *Yu* has the energy of two men. It is for this reason that I tried to hold him back.'

Confucius was asked the same question by two different disciples, but he gave them two different answers. He explained that he was trying to urge one who is excessively cautious and trying to hold back one who is more reckless. He saw his disciples as individuals who are constantly changing and growing and never failed

to take into account the personality of each disciple and his particular stage of development. Therefore, he tailored his teaching and responded to their individual needs and understandings.

In other words, Confucius was not simply following a lesson plan. The emphasis on operative knowledge applies to the teacher as well. He had an understanding of his students, their inherited expectations and predispositions, and he had the flexibility to adapt to where the students are in their understanding. There was never any disconnect between his teaching and the understanding of the individual students.

Confucius also values independent thinking in his students. For example, in *Analects* 7:8 Confucius mentioned that once he has given a student a corner of the square, the student should come back with the other three:

> The Master said, 'I never enlighten anyone who has not been driven to distraction by trying to understand a difficulty or who has not got into a frenzy trying to put his ideas into words. 'When I have pointed out one corner of a square to anyone and he does not come back with the other three, I will not point it out to him a second time.'

According to Confucius, the role of the teacher is not as a mere presenter of information, but as a knowledgeable guide to inspire the learners to think about things in a much bigger way than they have done before. The learners are then expected to conduct their own active and meaningful investigation into the topic.

In *Analects* 2:9, he viewed disagreement as a sign of independent thinking and was disappointed when a student did not disagree with him:

> The Master asked, 'I can speak to *Hui* all day without his disagreeing with me in any way. Thus he would seem to be stupid. However, when I take a closer look at what he does in private after he has withdrawn from my presence, I discover that it does, in fact, throw light on what I said. *Hui* is not stupid after all.'

In encouraging, and expecting disagreement and questions, Confucius can be said to be encouraging a polyvocal and inquiry-based form of learning, where the learner critically considered the information presented to him instead of passively memorizing it, and then internalized the information by putting it to practice.

Building from Prior Knowledge

The next major Confucian and the only other Chinese philosopher to have the distinction of having his name Latinised is Mencius (385–312 BCE). His teaching is canonized in a book by the same name. In the *Mencius*, he systematically elaborated upon Confucian teachings, explaining, interpreting, and deepening the discussion of certain themes. His philosophy is famously optimistic in that he believes in the inherent goodness of humans, and is captured in the often quoted phrase: "human nature is good" (*xing shan* 性善) (*Mencius* 6A:6).[2]

[2] All *Mencius* quotations are from Lau (1970). Lau uses of Wade Giles romanization are left as it is, although the rest of the chapter uses pinying Romanization, which is currently more popular.

Discussions in classical Chinese philosophy often revolve around the well-known supposed disagreement between Mencius and another great Confucius thinker, *Xunzi* (310 BCE to 219 BCE). The disagreement is often simplistically recounted thus: There is a thing in classical Chinese period that we call "human nature," Mencius famously said that "human nature is good," and *Xunzi* disagreed, notably saying instead, "human nature is evil." A thing cannot be both good and evil at the same time, so their positions are incompatible with each other. This disagreement is often presented to illustrate the different development of Confucian philosophy after Confucius, and how Mencius and *Xunzi* tried to shape the development according to their own understanding and views.

According to Mencius, all humans have moral inclination, in a famous passage – *Mencius* 2A:6 – he pointed to the four "hearts" in a human being, which, when nurtured, result in a morally cultivated person. Mencius thus emphasized the moral perfectibility of human beings, believing that each human possesses within him the necessary dispositions which would lead him to be a moral person. All that is needed is proper cultivation of these innate ingredients. For example, Mencius repeatedly compares moral development to the cultivation or growth of a sprout.

Xunzi, on the other hand, often compares moral development to straightening a board or sharpening metal. According to *Xunzi*'*s* metaphors, moral development is more of a process of indoctrination compared to Mencius' process of self-discovery.

A detailed discussion of the teachings of Mencius and Xunzi will take us far beyond the subject of this chapter; my minimal but reasonable characterization of the two philosophers here is to allow me to present a construction of Mencius' model as an example of teaching by "building from prior knowledge." Such a construction can be exemplified in the exchange between Mencius and King *Xuan* in *Mencius* 1A:7. This exchange is rather long and I have taken the liberty of doing a partial translation of it based on Lau's (1970) version.

> The passage begins with Mencius having an audience with King *Xuan* of the state of *Qi*. Mencius steers the conversation toward what is a true king. King *Xuan* who has brought misery to the people in his attempts at territorial expansion asks,
>
> "How virtuous must a man be like so that one can become a king?"
> Mencius said, "One who cares for and bring peace to the people, becomes a king. This is something no one can stop."
> *Xuan* said, "Can one such as I care for and bring peace to the people?"
> Mencius said, "You can."
> *Xuan* said, "How do you know that I can?"
> Mencius said, "I heard the following from *Hu He*:
>
> The king was sitting up on the upper hall and someone led an ox through the lower part. The king noticed this and said, 'Where is the ox going?' Someone responded, 'The blood of the ox is to be used for consecrating a new bell.' The king said, 'Spare it. I cannot bear to see it shrinking with fear, like an innocent man going to the execution ground.' Someone responded, 'In that case, should the ceremony be abandoned?' The king said, 'That is out of the question. Use a sheep instead."
>
> Mencius said, "I wonder if this is true."
> *Xuan* said, "It is."
> Mencius said, "This heart is sufficient to enable you to be a true king. The people all thought you were being stingy, but I have no doubt you were moved by pity for the animal."

> *Xuan* said, "You are right. How can there be such people? Although *Qi* is a small state, how could I be stingy about one ox? It was simply because I could not bear to see it shrink with fear, like an innocent going to the execution ground. So I exchanged it for a sheep instead."
>
> …
>
> Mencius said, "In the present case your kindness is sufficient to reach the animals, yet the benefits of your government fails to reach the common people. Why is this case alone different? Not lifting one feather is due to one not making the effort. Not seeing a cartload of firewood is due to one not using one's eye. Similarly, the common people not receiving peace is due to you not using your kindness. Hence, you not being a true king is due to you not acting; not due to you not being able to."

There are two parts to Mencius' argument and persuasion in this exchange. Firstly, he deduced an internal reaction from the behavior of King *Xuan*. Mencius told the king that he being moved by the sight of the ox means that the king already has the pity and kindness necessary to be a virtuous king. Now, King *Xuan* had not considered himself to be a virtuous person, and as a matter of fact, did not think he was particularly capable of being a virtuous king. With his example, Mencius was illustrating to King *Xuan* that he already had the moral capability to be a virtuous king.

Next, Mencius induced a state of cognitive dissonance by saying that the king's actions toward the common people and his internal feeling of kindness are in conflict. In essence, Mencius was taking the king's response in a particular context, discerning certain features that apply to other contexts, and then arguing that the response applies to other contexts as well.

If we move away from the ethical scenarios in Mencius' example and apply this method to other learning scenarios, it is basically a method of distilling out certain relevant knowledge that is present in the learner and helping the learner either logically extend those knowledge or applying those knowledge onto new areas, thereby increasing the knowledge of the learner.

The most famous and classical example of this in Greek philosophy is in Plato's *Meno. Meno* is a Socratic dialogue in which the main character, Socrates, attempts to determine the definition of virtue. Somehow in the middle of the dialogue, Socrates found time to teach a slave boy in Meno's house a geometry lesson.

Socrates demonstrated his method of learning by interrogating the slave boy who is ignorant of geometry. Socrates initially demonstrated that the slave boy is unaware of the length of side that must be used in order to double the area of a square with two-foot sides. By drawing geometric figures in the ground and subsequent discussion, he demonstrated that the slave boy is capable of learning a complicated geometry problem. Socrates concluded by claiming that learning is possible through a special "recollection" of knowledge from a past life.

We probably should not pay too much attention to Socrates theory of past life recollection, but the method employed by Socrates is relevant to our discussion. Socrates' method of teaching emphasizes using what the learner already knows and then presenting the information in different ways to create new knowledge. Socrates' example is a classic one and is readily available in books and online. In this chapter, I have highlighted certain qualities of key classical Chinese philosophers that might

have made them good teachers in their own time. I believe that those qualities are still relevant today in our own society. The criterion of what makes a person educated may be different, but the individual desire to learn and to make sense of the world is the same. People naturally observe, deconstruct, piece together, and create their own knowledge, and they learn best when their intrinsic motivation is harnessed by the teacher. Indeed, these very themes are developed further in the subsequent chapter.

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Chapter 4
Applying Disciplinary Intuitions to Classroom Contexts: A Constructivist Perspective

Michelle Tan

Introduction

The rhetoric of teachers adopting constructivist perspectives of learning to influence classroom teaching has dominated what teachers deem as student-centered teaching. From the historical contextualizations made in the preceding chapter, it should be clear that constructivist perspectives contest behaviorism's assumptions of *tabula rasa* and thus challenge the perspective that learning can take place through the mere transmission of content, facts, and principles (Aikenhead 1996; Driver et al. 1994). In situating learning as the learner making sense of the world around him/her, constructivism thus empowers the learner to construct his/her own ideas and knowledge about the world based on their prior understandings and experiences (Ausubel 1968; Driver 1983, 1989; Driver and Erickson 1983; Driver and Leach 1993; Iannello et al. 2011).

In this chapter, I attempt to situate understandings of Disciplinary Intuitions from the preceding chapters into the context of teaching and learning in a classroom, and to imagine how they may influence the classroom discourse to establish common ground between the teacher and the students, and to enrich student learning. In other words, in order to gain a deeper understanding of the roles Disciplinary Intuitions may play in learning environments, I explore how Disciplinary Intuitions may reframe our understandings and application of constructivist perspectives, particularly the conceptual change theory.

M. Tan (✉)
Faculty of Education, University of British Columbia, Vancouver, BC, Canada
e-mail: tanysmichelle@gmail.com

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Constructivism, Prior Knowledge, and Conceptual Change

Early studies in constructivism have focused on the cognitive changes that take place within an individual and individual sense-making (von Glasserfeld 1995), and the field has subsequently broadened to foreground noncognitive aspects that influence student learning, as well as the importance of cultural and social contexts. With regard to the latter, the research field has benefitted from the works of researchers such as Aikenhead (1996, 2000), Cobern (1996), and Jegede (1995), which elucidated the importance of the worldviews of students, their cultures, and subcultures to learning. The field has also drawn from scholarly works of Solomon (1993) and Lave and Wenger (1991) sociocultural paradigm and situated cognition respectively, which, together with several others, have helped advance personal constructivism into different forms of social constructivism.

In some sense, constructivism has gained popularity in the classroom because of its assertion for student-centered teaching over teacher-dominated pedagogies. For one, student-focused teaching is believed to reduce the risk of relegating teachers as mere technicians unreflectively enacting curriculum that has been designed by central authority. Furthermore, it is believed that a transformative classroom begins with the opportunities for teachers' own development of knowledge that frees them from being "disempowered in their role as information delivers, servants of knowledge and curricula produced elsewhere" (Kincheloe and Steinberg 1998, p. 13), and for teachers to be sensitized to students' learning processes and interests, even as these are placed at the center of the teachers' pedagogy (Goodson 1998). Alongside the practice of commonly framing classroom practices using constructivist principles and perspectives, the impact of constructivism on current research publications is still on the increase (Davis and Sumara 2003). Constructivism has been concomitantly contended and problematized. However, it is beyond this chapter to discuss the diversity in perspectives, criticisms, and arguments around constructivist epistemology and the different theories within (see, e.g., Davis and Sumara 2003; Fox 2001; Matthews 2002; Taber 2006).

Despite teachers not always having an extensive set of terminologies to describe their ideas in constructivism, a large proportion of teaching centers on moving students' understandings toward the canonical understandings governed by the discipline area. As such, we often hear teachers commenting on students' "*misconceptions*" that are in need of correction and "*Why don't students get it*?" In the same vein, the classroom discourse is often focused on changing these conceptions that students hold, although misinterpretations of constructivism that surface in classroom teaching exist (see Davis and Sumara 2003). The application of teachers of constructivist perspectives that foreground their desire to change and challenge students' existing understandings point us to an outgrowth of the constructivist movement: conceptual change theory (Hewson 1981; Hewson and Hewson 1984; Posner et al. 1982; Tyson et al. 1997); figuring more prominently in research literature in the 1980s and 1990s, even early 2000s, its influence still manifests in present-day classroom research and practice (Davis and Sumara 2003).

The understandings explored in this chapter provide glimpses of how pondering over Disciplinary Intuitions may deepen our insights to influence the designs of learning environments, and may provide teachers a way to make greater sense and meaning of the teaching and learning that takes place in their local school contexts; both of which are further explicated in the rest of the chapters in this book. Framing the current chapter in this way, we may begin to ask: So what can Disciplinary Intuitions offer to constructivist efforts that direct teachers to focus on student learning? How can Disciplinary Intuitions serve to promote transformations in a classroom? In some sense, the questions posed are rhetorical ones: they underscore how teachers develop their understandings about student learning.

I propose that the idea of Disciplinary Intuitions offers an often-neglected or taken-for-granted perspective to help teachers deepen and reframe their understandings of student "prior knowledge," and hence a challenge to the current dispositions often assumed by teachers.

In the rest of this chapter, I briefly introduce conceptual change theory and develop an argument around how Disciplinary Intuitions direct attention to the nature of "student misconceptions" (a term often used by teachers), even as the innateness of some intuitions provides the explanatory power to further understand the conceptions arising from these intuitions. Drawing from these perspectives, the implication for classroom practice is for a concomitant development of dispositions: for teachers to learn to be comfortable with a type of discomfort that may be manifested through cognitive dissonances. In navigating through these dissonances rather than ignoring or glossing over them, Disciplinary Intuitions may serve as a resource for learning.

Conceptual Change and Disciplinary Intuitions

Popularized by the teaching of science and mathematics, conceptual change theory is premised on how learning has the element of cognitive conflict (dissonance) and explicates the role of prior knowledge in students' learning (Pintrich et al. 1993). Conceptual change literature has described learning as conceptual capture or assimilation, exchange or accommodation (see Hewson and Hewson 2003; Posner et al. 1982; Strike and Posner 1985). According to Posner and colleagues (1982), students' organizing concepts may change from one set to another through *assimilation*, where students use the proposed concepts to deal with the new phenomena. They may also change through *accommodation*, which requires the replacing or reorganizing of concepts and occurs more often than assimilation. According to Hewson and Hewson (1984), "learning may involve changing a person's conceptions rather than simply adding new knowledge to what is already there" (p. 6).

The value of conceptual change theory is that it directs teachers' attention to students' prior knowledge and experiences. For example, in the teaching of genetics, understandings that are inconsistent with the canonical science of genetics have been uncovered, and were often relegated as problematic (e.g., Lewis and Kattman

2004; Tsui and Treagust 2004; Venville et al. 2005). Accompanying such efforts were advocates for conceptual change (Lewis and Kattmann 2004; Lewis and Wood-Robinson 2000; Tsui and Treagust 2004; Venville and Treagust 1998; Venville et al. 2005). Educational researchers have also focused on the exploration of students' conceptions using multiple interpretive frameworks that moves beyond cognitive aspects of learning (Lewis and Kattmann 2004; Lewis and Wood-Robinson 2000; Tsui and Treagust 2004; Venville et al. 2005). Alongside Printirch et al. (1993) assertion of the importance of the affective and social aspects, and building on Strike and Posner (1985) as well as Chin and Brewer's (1993) works, the use of epistemological, ontological, and social/affective perspectives to explore conceptual change in genetics were supported (Tyson et al. 1997; Venville and Treagust 1998). For example, Venville and Treagust were interested in perceptible ontological shifts in the way students viewed genes from being particle-like to a productive sequence of instruction that would code for proteins. So how can Disciplinary Intuitions offer to these efforts, and similar ones, that aimed to promote teachers' focus on student learning? In the next section, I attempt to situate proposed understandings of the nature of Disciplinary Intuitions into how one may enrich their understandings of students' prior knowledge and experiences.

Disciplinary Intuitions as a Resource to Address Student Misconceptions

In the preceding chapters, the nature of Disciplinary Intuitions was discussed, and was accompanied by an explication about how Disciplinary Intuitions may be attributed to the intuitions and logics we are equipped with to survive and adapt in the world (Pinker 2002). Similarly, concurring with Pinker's assertion that our reasoning faculties are based on core intuitions that enable us to analyze the world, what has been argued for is that intuitions can be developed. Drawing from the arguments laid out in the previous chapters, we proceed by asking the following questions: What is the nature of students' understandings in light of Disciplinary Intuitions? How can an understanding of Disciplinary Intuitions influence a classroom discourse?

Misconceptions, preconceptions (Novak 1977), and alternative conceptions (Driver and Easely 1978) have often been used interchangeably in research literature – in this chapter, the varying conceptions will be collectively termed as "misconceptions" as often used by teachers, although they do in fact differ in meanings. Extending these ideas that attempt to account for students' *prior knowledge*, attention has also been directed to conceptual and alternative frameworks that students possess; the latter can be regarded as transcontextual (Engel and Driver 1982) and as generalized nonindividual descriptions that attempt to capture "both the explicit responses made and the construed intentions behind them" (Gilbert and Watts 1983, p. 69). As described by Driver and Erickson (1983), the notion of a conceptual framework is underpinned by Strauss's (1981) argument that much of students' common-sense knowledge (constituting their prior knowledge) is sponta-

neous and universal, which is tied to "complex interactions between the sensory, the environment that supplies the information of our sensory systems and the mental structures through which we organize the sensory information" (Strauss 1981, p. 297). Driver and Erickson has also traced the origins and influences on students' conceptual frameworks to the importance of kinesthetic or sense experiences (e.g., di Sessa 1983; Strauss 1981) and to language and metaphors (e.g., Lakoff and Johnson 1980). Building on Lakoff and Johnson's work, Lakoff and Núñez (2000) similarly demonstrated through mathematics that metaphors can be understood in terms of conceptual structures, and these conceptual metaphors are common in everyday thought and language.

diSessa (1988) has described "knowledge in pieces" such as phenomenological primitives ("p-prims") as fragmentary substructures of cognition. diSessa's view of intuitive knowledge describes p-prims as unstable, nascent, and emergent conceptions, as opposed to the more stable – yet inaccurate – cognitive structures of pre- and/or misconceptions (1983, 1993); in fact, from a constructivist perspective, the very existence of the latter has been questioned by diSessa and his colleagues (diSessa and Sherin 2000; Smith et al. 1993) in the first place.

It can be reasonably argued that diSessa has his roots in Piagetian – and, consequently, Vygotskyian – understandings of learning and development. It was in fact Vygotsky who made the distinction between a learner's everyday concepts and nonspontaneous concepts. Vygotsky described the former as formed during a learner's activity through interaction with social others in everyday life; thus, for example, everyday concepts manifest themselves in the way learners use words in everyday language, as opposed to scientific concepts which are mastered during systematic instruction.

Vygotsky theorized that spontaneous, everyday concepts are not binarily displaced over time by scientific concepts, but each is dependent on the other in a dialectic coupling which serves both to reinforce understanding and arouse curiosity. When a learner is confronted with novelty in an everyday context, he or she gradually develops the verbological structure which brings into existence the everyday concept; Vygotsky described such verbological structures as developed initially through the accumulation of "syncretic heaps" and then through the formation of complexes (or pseudoconcepts). Because of this gradual process (from heaps to complexes to concepts), the development of everyday concepts was described by Vygotsky as being from bottom to top.

In this way, he contrasted the development of everyday concepts with the development of scientific concepts, the latter of which Vygotsky (1986) described as being from top to bottom. In such a framing, Vygotsky was therefore able to claim that the development of scientific concepts starts with a formalized (often verbal) explanation, and is subsequently connected to the learner's experience. The initial (verbal) definition is given within a fixed system and subsequently "descends" to the concrete phenomena that the learner encounters in everyday life.

Vygotsky went further to recognize the reciprocal dependence of everyday concepts and scientific concepts. He claimed that the development of both was two "parts of a single process: the development of concept formation which is affected

by varying external and internal conditions but is essentially a unitary process, not a conflict of antagonistic, mutually exclusive forms of thinking" (Vygotsky 1986, p. 157). Vygotsky continued:

> [I]n working its slow way upward, an everyday concept clears a path for the scientific concept and its downward development. It creates a series of structures necessary for the evolution of a concept's more primitive, elemental aspects. Scientific concepts – in turn – supply structures for the upward development of a child's spontaneous concepts toward consciousness and deliberate use. (Vygotsky 1986, p. 194)

Luria (1973) described this dialectical coupling as "interfunctional organisation," in which "scientific concepts rise on the foundation of everyday concepts and – in the process – fundamentally change the everyday concepts by drawing them into systemic relations."

In light of the aforementioned, it may be suggested that Disciplinary Intuitions serve to deepen our understandings of conceptual frameworks. For one, the ability to attribute some of student understandings and conceptual frameworks to Disciplinary Intuitions helps us to trace the "origins" of these understandings. Borrowing from Pinker's (2002) assertion, there are core intuitions that exist in humans, and he has come up with a defensible list of cognitive faculties and core intuitions such as an intuitive physics, an intuitive version of biology or natural history, an intuitive engineering, a spatial sense, a number sense, language and others – all of which help the mind frame issues and experiences in everyday life to classroom learning. These intuitions may, in constructivist and conceptual change terms, enable the learner to construct his/her understandings. Similarly, Lakoff and Núñez (2000) have made bold assertions that conceptual metaphor is a "neurally embodied fundamental cognitive mechanism that allows us to use the inferential structure of one domain to reason about another" (p. 351). Both Pinker and Lakoff and Núñez have highlighted how our mental faculties and innate intuitions (and I argue that some of these constitute and help develop Disciplinary Intuitions) play a role in learning.

In spite of the uncertainties that may well attest to the inherent complexity in learning and in understanding learning in relation to Disciplinary Intuitions, the point to be made is that *Disciplinary Intuitions is a valuable resource to enhance learning*, even as its power lies in how these intuitions constitute a process by which other resources are drawn upon to help the learner engage in an experience of the world as an embodied experience of learning. Conversely, these very resources may also account for the barriers to learning and point toward directions where they may be overcome, thus turning these barriers around to promote learning.

Implications for Classroom Practice: Challenging Dispositions

As exemplified earlier, Disciplinary Intuitions may be manifested in the kinds of understandings that have often been labeled as a challenge to student learning; those that run up against the counterintuitive understandings as presented by canonical

knowledge of a particular discipline (Hewson and Thorley 1989). In attempting to frame student misconceptions using Disciplinary Intuitions, what is contested is the speed at which teachers are often too quick in wanting to change students' intuitive understandings.

At an epistemological level, there is a need to problematize teachers' dominant disposition in uncritically viewing student misconceptions as wrong and thus the central focus of teaching and learning as merely changing one's conceptions.

The concern is: while the constructivist movement served to direct teachers' attention to student learning and hopefully to break the technical culture of curriculum implementation, the quest to correct students' conceptions by uncritically and almost mechanistically packing them against standardized curricular content seems to be but a variant of the technician model to teaching for the unreflective teacher (Tan and Nashon 2013). Until and unless teachers begin to reflect on the nature of students' understandings and misconceptions, and place them at the center of the teacher's teaching (Goodson 1998), the *status quo* of teaching may be perpetuated in the masked and superficial implementation of changing students' conceptions as if students were Blank Slates that could have their knowledge erased and replaced, almost as easily as they were first written onto the slates.

Second, in framing learning as assimilation or accommodation of new conceptions, and in focusing on the conditions to promote conceptual change (Hewson and Hewson 1984, 2003; Posner et al. 1982; Strike and Posner 1985), it runs the risk of forgetting about the multivalent nature of learning, as likewise cautioned in literature. What has been witnessed in the past decades of dialogues around conceptual change and teaching has been the importance of cultural and social contexts and noncognitive aspects that promote learning (as reviewed earlier) – they attest to how learning can often be framed using multiple-interpretative frameworks and learning mechanisms. But beyond frameworks and mechanisms, what has been less discussed in the literature, and we argue is part of this multivalent nature of learning, is the *disposition* of students and teachers toward learning, which may be influenced by their understandings of learning itself.

Learning can be influenced by some innate Disciplinary Intuitions that manifest in our responses, that constitute and reframe our experiences, and that help us select and impose our propositional knowledge, tacit knowledge, and experiences in particular contexts to promote, though not necessarily promise, the production of new knowledge. However, intuitions may often run counter to propositional knowledge such as the canonical knowledge in science, as manifested in the large body of literature in the 1980s and 1990s that sought to uncover students' misconceptions, alternative frameworks, and children science. *When* students' understandings and misconceptions are situated in Disciplinary Intuitions – and I am by no means asserting that *all* understandings and misconceptions may be fruitfully discussed in this way, but *when* it is useful to frame it in this way – it provides the explanatory power to elucidate the nature of students' recalcitrant misconceptions and its partner, the cognitive apartheid; thus addressing the teachers' question: "Why don't students get it?"

Beyond the provision of explanatory power, what is legitimized is the discomfort with intuitive understandings that runs counter to canonical knowledge. This stands in contrast to how student misconceptions are commonly considered erroneous (thus the popular term of "misconceptions" in the first place) and in need of immediate correction, alongside the removal of cognitive conflicts and dissonances. Again, such a proposition may prove valuable in light of how students are often unready to risk altering a useful commonsense conception in favor of a counterintuitive abstraction that has been advanced by the teacher or a textbook (Cobern 1996; Hills 1989).

It also addresses the underlying assumption, or rather, it addresses the misinterpretation teachers often hold about conceptual change being all about changing students' conceptions, rather than an opportunity to reflect and ponder over its constructivist origins that directs attention to how people learn (Davis and Sumara 2003). However, the "legitimatization" of these counterintuitive understandings in a classroom does not necessarily mean that they now enjoy a greater status over canonical disciplinary knowledge in relations to truth claims, or that they have greater explanatory power to explain various phenomenon, nor that they may promote greater learning in the cognitive sense; but that such a legitimatization as some origins of ideas being "innate" further explicates the relationship between disciplinary knowledge, everyday conceptions, and student knowledge. Put simply, it offers opportunities to further dialogue about learning.

Furthermore, what has been granted is a way for students to reconcile the cognitive and affective dissonances that may occur when their everyday conceptions come head-on with canonical disciplinary knowledge. In a similar vein, what is advocated is for teachers and students to learn to be comfortable with the discomfort of cognitive dissonances and counterintuitive understandings; a reconciliation with how some of this discomfort results from the inherent nature of the ways in which we are inclined to experience the world because of our own intuitions. Moving between the space of discomfort and students' confrontations with counterintuitive understandings grants teachers greater opportunities to reflect on the nature of what they term as "misconceptions" and their relationship to learning.

Such a perspective may be important in view of the kinds of learning that takes place beyond the classroom contexts. In several cases, learning may occur when the possibilities and limitations of various intuitions and understandings are put to test, and are applied to multiple contexts (Bjork and Richardson-Klavehn 1989) in order to promote the transfer of learning, that is, what has been learned in one context to new contexts (Brynes 1996). By being comfortable with a sense of cognitive discomfort and by inculcating the willingness to hold within the same space both intuitive and counterintuitive understandings, we may begin to explore and engage students in dialogues around their own intuitive understandings and the embodied expressions of their own knowledge; to encourage classroom discourses around the knowledge people bring into the learning situation and how they extend it to other learning contexts. In other words, in viewing learning as a transfer from previous experiences (Bransford et al. 2000), we may reduce and even evade the shame often felt by students – particularly in East Asian classrooms – by acknowledging how some of our Disciplinary Intuitions and hence understandings are "natural," and shared across different individuals.

In some sense, the problem lies not with the problematic nature of various intuitive understandings that may hinder some kinds of learning, but with how they are dealt with in a classroom. Seen in this light, the position asserted here thus resonates with earlier work that draws attention to students' affective aspects in learning (e.g., Printirch et al. 1993). For example, if students undergo conceptual change and develop understandings that genetically modified (GM) varieties are no more dangerous than "natural" foods (Pinker 2002), then the intuitive understandings may be developed in new ways. One possibility of such occurrence may be the student's ability to recognize and explore the blanket fear of GM foods against new understandings of genetic engineering that are more consistent with canonical science of genetics; for the student to develop an openness to work within the space of cognitive dissonance. In other words, if students are allowed to feel comfortable in being able to hold on to their ideas (and even fear) of genetically modified foods a little longer than would traditionally be accepted, there just might be greater opportunities to engage students in larger ideas around living things and their "essences" – a more abstract idea that may influence their conceptual framework.

Furthermore, it may propel teachers and students to realize that perhaps it is this intuitive understanding that often led students to relate genes with physical appearances (rather than to the functional aspects of genes, which is believed to be a more helpful way to promote canonical understandings of genetics); especially since appearances is a visible sensory experience of the "essence." Thus, an alternative explanation is provided, extending the popular attributions of students' understandings to the influence of media and culture. Framed in this way, the world that students authentically live in may find a more welcoming space in the classroom where the subculture of schooling (Aikenhead 1996) and the subject discipline typically dominate; where the confrontation between the two is now made a comfortable space of learning rather than a contentious one.

In incorporating the notion of Disciplinary Intuitions into our perspectives of learning, and in inculcating our acceptance of various intuitive understandings as being innate and thus worthy of exploration and discussion, it may also avoid the extreme response of evading any evidence of students' misunderstandings: by resorting to dumb down the "correct" ideas as if students were, ironically, Blank Slates. We see a similar argument being made even as researchers like Gilbert and Watts (1983) who cautioned about the dangers of a classical view of conceptualizing misconceptions as "simply wrong": as manifested in the illusion of how simple repetitions may engender formal understandings.

Concluding Remarks

It has been argued how students' difficulty in learning may be attributed to the understandings that they bring into the classrooms, and that these understandings may have arisen from the Disciplinary Intuitions that they draw upon as a resource to engage in meaning-making in this world. It has also been discussed how Disciplinary Intuitions challenge our efforts to change students' conceptions all too

quickly without giving much thought to the nature of the conceptions, and, as a result, may have missed precious learning opportunities.

In centering the discussion on very limited examples, I acknowledge that while some misconceptions that students have may be more easily accounted for (at least in part) by Disciplinary Intuitions, others may not be that easily identified in view of the tacit nature of our intuitions, and in view of the complexity of the embodied mind (Lakoff and Núñez 2000) that accounts for the complexity experiences play in learning, as well as the complexity involved in our conceptual mechanisms.

In spite of these limitations, and in an attempt to situate Disciplinary Intuitions into the classroom contexts, I have focused on how these intuitions may be opportunistically tapped upon as a resource for learning. Admittedly, the chapter could have been positioned to demonstrate and explicate how core intuitions may be used to promote learning of more advanced concepts. But in some sense, these ideas have been well-explored by others, although not necessarily through the direct employment of the terms "Disciplinary Intuitions" (e.g., Pinker 2002; Lakoff and Núñez (2000). Thus, I have chosen to explore an often taken-for-granted position of teachers and occurrence in conceptual change classrooms: that teaching conceptual change is dominantly about changing students' classroom practices. In challenging that notion and proposing that students' misconceptions may be used as important seeds for meaningful dialogues, not only do we absolve the dichotomy between "right" and "wrong" that often perpetuates a "dumbing down" effect on students, it also beckons the teacher to consider students' understandings in more reflective and respectful ways; the latter allowing a coexploration of these very understandings. Framed in this way, Disciplinary Intuitions provides a refreshing way of thinking about how students' learning processes and interests can be placed at the center of the teachers' pedagogy (Goodson 1998), and a concomitant escape from applying conceptual change strategies as mere technicians. In privileging classroom discourses rather than mere correction of conceptions, in foregrounding changes in teacher dispositions rather than teacher acts and strategies of teaching per se, Disciplinary Intuitions points the way forward by reminding us of those classroom aspects that may well be relegated to the background; by urging us to revisit the constructivist origins that place the student (with his or her Disciplinary Intuitions) and the learning as focus of our classroom discourse.

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Part II
Delving into Disciplines

Chapter 5
Developing Disciplinary Intuitions in the Natural Sciences

Michael Tan and Michelle Tan

Introduction

Alfonso Cuarón's 2013 space drama *Gravity* has been nominated (and won) so many awards worldwide, that just the awards alone for the film have their own separate entry in Wikipedia. What is it about this film that has enabled it to capture the imagination of audiences? There are many factors, from the human drama, to the score, to the themes of wilderness and resilience. Of particular relevance to this book is the depiction of space as a very alien environment (without there being any alien creatures in the film). What is it about space that makes it so alien to an earthbound human audience?

It might be reasonably argued that phenomena and their attendant intuitions might be organized according to simplicity. Simple phenomena and intuitions are those which arise out of simple and straightforward application of a small number of physical laws, and are consequently easily explained in a manner in accordance with those laws. Complex phenomena and intuitions arise out of the application of many interacting laws.

In this sense, simple phenomena are difficult to find in everyday experience, because all physical phenomena in human everyday experience are affected by most of the following factors: air pressure, air resistance, friction, gravity, in addition to Coriolis forces, wind, and so on.

M. Tan (✉)
Centre for Research in Pedagogy and Practice, National Institute of Education, Singapore, Singapore
e-mail: michael.tan@nie.edu.sg

M. Tan
Faculty of Education, University of British Columbia, Vancouver, BC, Canada
e-mail: tanysmichelle@gmail.com

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Further, the particular situation of humans itself adds issues. For example, gravity is experienced as a constant force, whereas we know that gravity decreases as one travels further away from a massive body (the inverse square law).

For instance, Newton's apple was affected by air resistance, gravity, and wind. Further, if Newton had merely measured the acceleration of objects in the laboratory (even taking into account air pressure, and so on) without relying on observations of the planets conducted by, for example, Hooke, the logical conclusion would be that "all objects are pulled towards the Earth with an acceleration of 9.8 m/s^2," which is sufficient for the case of objects at sea level but not exactly useful as a physical law.

In this chapter, we shall think through some pedagogical implications for developing Disciplinary Intuitions in the natural sciences. The question that guides us is the nature of scientific knowledge—what, if any, are the underlying regularities that inform our construction of science? If these regularities exist, how could we use them to generate intuitive understandings in learners? Concomitantly, how might we construct a universe of simple but increasingly complex phenomena and intuitions that are consistent with, and hence easily "bridged" to, the laws of physics as they are taught—that is to say, they do not require exceptionality or the application of laws that are judged to be beyond the ability of the students?

Like many of the other authors in this book, our claim is that developing this constellation of simple intuitions requires the repeated and continual embodied experience of simple phenomena. It is not enough to experience a phenomenon once or a few times; the human mind has a surprising ability to categorize phenomena as "exceptions" and hence discard them from its schema of intuition.

A key tenet of Disciplinary Intuitions is the notion of disciplinarity—that our intuitive understandings of reality correspond closely to disciplinary boundaries, and that these boundaries correspond closely to nonarbitrary, real distinctions between phenomena. In considering scientific knowledge, the immediate contrast would be with natural philosophy, the collected wisdom about the functioning of the universe that we have accumulated through the ages.

In a sense, the ancient prescientific precursor to modern scientific knowledge corresponds well to what we may term as intuitive appreciation of the way nature works: because we have experience with propelling objects, and sense that the moment we stop applying a force, objects cease their motion; therefore motion implies the application of a force; consuming extracts of particular plants and animals would confer on the consumer characteristics of the consumed; we are at the center of the universe. We now perceive the universe differently and have changed how we frame questions suitable for inquiry, especially in the counterintuitive nature of contemporary science: we are not in the center of the universe; motion does not imply force; particles possess wave-like behavior; we are self-replicating carriers of genetic information; the list goes on.

The Example of Genetically Modified (GM) Crops

As cited by Pinker (2002), intuitive biology foregrounds the concept of an invisible essence residing in living things, and this essence confers living things their powers and form. Such intuitions allow one to deduce some basic concepts in biology and about

living things, such as how a raccoon will have raccoon babies and a seed taken from an apple plant may develop into an apple tree (Pinker 2002). Extending beyond biology, although Lakoff and Núñez (2000) did not use the term "intuition," they likewise borrowed from the folk theory of essences that constitutes our everyday conceptions about physical objects to explain how algebra is about essence; that "every specific thing is a kind of thing" (p. 107) and that "everything has an essence" (p.108).

These very intuitions, however, may also render canonical disciplinary knowledge as counterintuitive (Hewson and Thorley 1989), and hence the need for students to unlearn the understandings that may arise from these core intuitions. We see an example of this provided by Lakoff and Núñez (2000): in relation to the conceptions of points and the continuum, discretized space in mathematics differs from our ordinary conceptions of space. The latter may be influenced by our physical experiences, and may also be influenced by our core intuitive spatial sense (Pinker 2002).

Similarly, in the context of invisible essence residing in living things constituting an intuition that is often tacit rather than explicit, we are able to witness its manifestation through students' blanket fear of all artificial and genetically modified (GM) foods. (This phenomenon has been similarly identified by Pinker.) Conversely, natural foods may be deemed to have the pure essence of a plant or animal—from personal experiences teaching high-school genetics, we anecdotally attest that this is common amongst students. Consequently, this may result in what Cobern (1996) and Jegede (1995) have termed respectively as cognitive apartheid and collateral learning, where students may risk holding oppositional conceptual understandings that are applied in and out of school contexts, and where students view school science content as having little or no relevance to their everyday life. In this case, students may not be able to reconcile their intuitive fear about GM foods with their potential benefits as promoted through the school science curriculum, such as their potential to alleviate part of the world's food problems.

As discussed in Chapter 2, Disciplinary Intuitions may help the learner sift and *tacitly select* from a vast amount of information, prior knowledge, and various episodes of one's prior experiences to make meanings of various phenomena experienced and to solve problems. In this view, Disciplinary Intuitions provide glimpses of how student misconceptions may be accounted for, beyond the culturally and socially dependent factors explored in conceptual change literature. The proposition made is that this very selection of relevant (or inappropriate) pieces of information, prior knowledge, and experiences as shaped by our intuitions, influences the perceptions and experiences of students. For instance, in the case of students' blanket fear of GM foods, this may be understood as how an intuitive understanding of an invisible essence residing in living things may have disposed the student to associate the process with violations of the essence of living things (Pinker 2002), and to subsequently frame the genetic engineering processes using their prior experiences and knowledge of mutants, regardless of whether they are accurate conceptions or not, regardless of whether they came across mutants through textbooks, the mass media, or other means (Tan and Nashon 2013).

In light of Chapter 1 as well as the preceding argument, student conceptions are grounded in the notion of "embodiment," akin to Lakoff and Núñez's (2000)

notion of the embodied mind: namely, an embodiment grounded in the learner's experiences, which makes use of a variety of metaphors and cognitive mechanisms, of which some are innate, and others have developed over time, while others develop only with special training. Phrased differently, the selection and application of prior knowledge and experiences, as embodied in the mind (Lakoff and Núñez 2000) and explored in classroom teaching, is tantamount to a complex interactive process that continually shapes the learner's experiences and knowledge. We assert that the understandings arising from these intuitions may be challenged to promote learning. In the example mentioned earlier, students may develop greater skepticism toward GM foods and reinforce cognitive apartheid. Concomitantly, their innate intuitions about the essence in living things may be reinforced. Conversely, should the student, for some reason, undergo conceptual change by developing understandings that GM varieties are no more dangerous than "natural" foods (Pinker 2002), then the intuitive understandings may be developed in new ways, or more accurately, in ways that run counterintuitive (Hewson and Thorley 1989) to these very innate intuitions.

An Example from the Water Cycle

Disciplinary Intuitions may account for some of the barriers students experience in conceptual change. Pinker has demonstrated how our intuitive physics allows us to experience falling objects, how they bounce and bend; with the core intuition being about the concept of the object and how it follows laws of motion and force. This ability is based on scientifically inaccurate conceptions of impetus, and gives rise to the popular motion-implies-force misconception that teachers of contemporary physics work so hard to get students to unlearn (e.g., Howe et al. 2013; and Chapter 14 of this book). According to Pinker, these intuitions form a more rudimentary and "medieval" (p. 219) conception than those found in Newton's laws; that is, these intuitions may provide some explanatory power as to why students have difficulties understanding and applying Newton's laws to explain everyday phenomena.

The challenge for contemporary science education has been to find means to address this gap between intuition and knowledge, spawning a highly productive research agenda beginning in the mid-1980s to the 1990s (see, e.g., diSessa 1993; Posner et al. 1982), searching for means to mitigate the effects of scientific misconceptions. In a change retrospectively predictable, the field has since moved on to consider epistemic concerns—what is it about scientific knowledge and practice that make it a discipline and practice distinct from others?

The present authors were involved in a project that taught the water cycle to Grade Five students through an experimental method of digital video-making. The purported benefits of such a method were its interdisciplinary approach, whereby learners would pick up skills of English literacy and science at the same time. Also foregrounded was the notion that in making videos, students would have to develop a diverse set of grounding contexts from which to develop appropriate theoretical

understandings. As an instructional strategy, this approach leveraged the affordances of digital video supporting sharing (and thus community critique) and rapid prototyping, and was ideally suited to the development of particular dispositions currently favored—that of risk tolerance, openness to collaboration, and task persistence. Analyzed in those terms, the project was a fair success, engaging students in meaningful activity and developing their nascent twenty-first-century skills.

However, from our Disciplinary Intuitions perspective, there is a sense in which this strategy, and by extension, many others similar to this, lack something valuable, especially the disciplinary appreciation of science. Here, it is hard to stress this too much: the Disciplinary Intuitions approach is not one of a conservative backlash and a proposal to return to a mythical past where disciplinary expertise was respected. On one level, there is a curriculum argument here over which dispositions are valuable: the recently much vaunted twenty-first-century competencies for which numerous arguments have been made, or the more classically understood dispositions associated with the practices of the "scientific method." On another, there is a pedagogical argument over the best ways to bring about these desired dispositions. In terms of curriculum, there is no intrinsic conflict: many of the desirable dispositions nurtured in science are similarly valued today. Qualities such as open-mindedness, tenacity in the face of ambiguous task parameters, curiosity, and the importance of collaboration are enduring values. However, less obvious are the kinds of dispositions and intuitions specific to science itself. Specific to this case then, the scientific principle underlying the water cycle is the principle of conservation.

The principle of conservation is a simple idea that has an amazing degree of application in numerous contexts. In the water cycle, matter (in this case, water) is conserved; water cannot spontaneously vanish, and neither can water appear out of nowhere. At later ages, students are then exposed to the principle of conservation of energy, or in chemistry, chemical equation balancing principles in which essentially atoms are conserved, and on to such advanced concepts as the Navier-Stokes equations that describe fluid behavior and allow us to do such things as predict weather and design high-performance aircraft. Numerous scientific discoveries can even to be said to be derived by assuming conservation, and then attending to the empirical data in a hypothetico-deductive manner. As curriculum designers then, it would be wise not to treat the topic of the water cycle as mere content to "cover," but an instantiation of a more general and consequential principle. The challenge is not necessarily to be met by showing the diverse conservation principles in hopes of impressing upon them the centrality of the principle, but by developing what we may term here as an appropriate intuitive appreciation such that learners can make the connection with subsequent topics.

How can this be done? To begin with, we identify the innate sense associated with the theoretical knowledge, in this case, an intuitive physics that derives from our interactions with objects. The core intuition here is that of object permanence, associated all the way back to infants' entertainment at peek-a-boo indicative of their inability to grasp the concept (Baillargeon 1985). To introduce mass conservation as an abstract concept, it is important that learners have had these experiences

with permanence, in addition to phase changes as the connecting principle that allows matter to still exist even though water seemingly vanishes when evaporated. Also important is the principle of boundedness of the system—conservation principles are always localized to certain boundaries which mark the inside area of interest from the outside. With respect to the water cycle, probably the most challenging concept is the notion of the entire earth as the boundary for the system, as the concept of the earth as a globe is not within the experience of most young learners. Still, for most learners at Grade Five, sufficient abstract extension of earlier experiences should have taken place such that all these concepts fall into place, ready for the building up of the concept of conservation. These take the form of, for example, metaphorical explanation, various forms of media, and, today, digital simulations that give students vicarious experiences through control of online avatars.

Such an approach echoes Ben-zvi-Assaraf's (2005) observations that students in a "broad, context-based, unit" on the water cycle showed a "distinct improvement" in their ability to form mental models of complex processes, and were "better able" to identify and anticipate relationships.

In short, this perspective is not supposed to be some radical innovation; the "magic" derives from the principles of selection, sequencing, and pacing learning experiences, many of which have been traditionally established as effective pedagogical strategies. The difference here, however, is a more deliberate and intentional process, informed in large part by disciplinary knowledge—how pieces of knowledge connect to one another according to the idiosyncratic structuring principles of each discipline. And, to reiterate the concept first introduced in Chapter 2, while knowledge may be socially constructed, such constructions are nonarbitrary, being bounded by the necessity for correspondence to a stable reality. Second, we theorize that certain experiences are likely to be more educative than others, the general principle of which are informed by the concepts developed by embodied cognition and the concept of innateness of cognitive modules. In this example, while digital video-making may be a good activity to develop particular dispositions, it may be less than ideal for developing deep and long-lasting appreciation of disciplinary forms of knowledge.

But What Happens for Counterintuitive Concepts?

The case of the water cycle has been the "low challenge" concept: with appropriate experiences that need not be deliberately programmed, most learners by a particular age would come to accept rather naturally the concept of mass (and other forms of) conservation within the boundaries of a predefined system. The problem for science, as alluded to in the beginning of the earlier section, is its counterintuitive nature (see, e.g., Wolpert 1992)—for millenia, humans have experienced the phenomena of sunrise and sunset, and only in the wink of human history have we decided that the better explanation was that of heliocentrism.

One of the seminal researchers on children's conceptions about weather phenomena is Henriques (2002). Her review of the literature was initiated on the basis that relatively few studies had been carried out to understand what children think about topics in the earth sciences. One of her most salient findings is that while weather is ostensibly a topic within the earth sciences, many of the misconceptions students held regarding weather originated from the natural sciences; examples included properties of water, and phase changes and the water cycle. Her often-cited cautionary conclusion was that "in many cases, students' misconceptions are not addressed in the curriculum, allowing them to exist unchallenged."

Some of the studies which Henriques unearthed in her review were Sere's (1985) and that of Driver et al. (1994). These just served to highlight particular misconceptions which students held – for example, that air has weight was challenging even for high-school students (Sere 1985) and that air exerts pressure only when it is moving downward (Driver et al. 1994). With regard to humidity, Bar (1989) commented on the difficulty children have in understanding air as a "permanent substance," and how this, in turn, led to what Russell and Watt (1990) observed was the difficulty that fifth-graders had in identifying air as the final location of evaporating water. Lee et al. (1993) built on this preceding work to suggest that such difficulties of understanding persist into students' middle-school years. Likewise, when Aron et al. (1994) conducted a study on participants ranging from preservice teachers and students of various ages (from middle-school to college) on topics such as air pressure, humidity, and cloud composition, their conclusion was that across all age levels, people did not understand weather concepts.

This alarming pattern of results arising from research into children's understanding of natural weather events has continued beyond Henriques's study and into the early twenty-first century. In their 2008 study on middle-school and college students' conceptions about extreme weather events and hazards, Polito, Tanner, and Monteverdi come to the rather damning conclusion that while "conceptual research in science education has advanced during the past 50 years… conceptual research in meteorology is clearly lacking… for example, there are apparently no research articles about alternative conceptions of weather in the Journal of Geoscience Education, the main publication for educational research in the geosciences."

Why would science favor the counterintuitive explanation over other alternatives? At the surface, the reflexive response would be that this is simply because science favors the truth, intuitive or otherwise. However, this merely leads to more questions than we can answer here—how does one know what truth is? Scientists also often favor the elegant solution—one that uses a parsimony of explanatory mechanism for maximal applicability, to the point of throwing out perfectly admissible data in the quest for beauty. For instance, Wolpert (1992, p. 96) recounts the case of Milikan, who in his quest for the quantum of the electronic charge had developed a system of categorizing the results in his notebooks, discarding poor results interpreted as being a "poor run" which did not build toward his preferred value. One cannot help but recount Meno's paradox here about the impossibility of finding new knowledge: if we do not know what we are looking for, we would not know when we found it; if

we did know what we are looking for, then the investigation is unnecessary. Still, this is not to support the stance that knowledge is fabricated; just as the resolution of Meno's paradox lies in the quiet pointing out the false dichotomy of knowing/not knowing, we are never really completely ignorant, and can possess partial knowledge from which we can then recognize the epistemic value of subsequent empirical findings or theoretical propositions.

It is in this manner then that we see avenues for resolution of our problem. Partial knowledge, for us, need not be knowledge "in the head" expressible in linguistic propositions. Learners need more and better embodied experiences from which to draw metaphorical extensions that ultimately become their theoretical understandings, and instructors, as designers of these experiences, need to be keenly aware of the cognitive leaps which build from these experiences to versions expressible in conventional linguistic terms. Just as elementary school teachers make use of concrete manipulatives to teach arithmetic operations, science teachers need to make use of a wider variety of diverse experiences, not necessarily the kinds typically presented in the science laboratory, in order to build up a diverse enough stock of experiences from which to develop theoretical knowledge. To be sure, the research literature has even reported on the role played by gestures (e.g., Alibali and Nathan 2012)—there are some gestures that are more productive than others, and are ways to activate our embodied understanding through signaling systems which include the entire body (and not just language). For counterintuitive concepts, perhaps the best means available remains a simple and direct conscious flagging out to learners of the counterintuitive nature of the concept, working from the limits of metaphorical extension of our embodied experiences.

When we come to scientific knowledge, we encounter perhaps some of the biggest challenges to effective learning of abstract and theoretical understandings. Here, the capacity of the human mind to recursively build upon metaphors is probably key to the entire process. As educators, the challenge is exciting: how does one educate the *whole person*, using the full range of channels of experiencing and communicating information that we now know to use? It certainly is an exciting time to be an educator.

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Chapter 6
The Nature of Intuition in Design

Mohamed Suffian Bin Mohamed Amin

Introduction

Intuition plays an important role in design, especially when it comes to inducting novice designers (such as the 13–14 year olds described in this chapter) into the act of designing. Humans, naturally learn to draw (and sketch) before reading and writing. Drawing and sketching are innate visual abilities in humans. Such abilities can be activated through purposeful activities that could easily be adopted as means to introduce pupils to design. Figure 6.1 below shows a simple design activity where a Grade 8 pupil uses lines and circles to 'design and make a notepad holder'. As part of the activity, the pupil was required to draw random lines and circles into a square template and later trace the outline of the shapes and lines drawn (Exemplar 2.1). In the latter part of the activity, the shapes were then extruded to 3D (Exemplar 2.2) and eventually conceptualised (Exemplar 2.3) after going through development process in terms of sizing and assembly.

The activity described in the paragraph above is an example of how intuition is used to surface innate visual ability in a child to introduce him to design. In this activity, the use of lines and circles were intentionally chosen to allow him to tap on his prior experiences when designing the notepad holder.

Our world today is becoming increasingly visual. Eye-catching advertisements, innovative products and fashionable clothes are manifestations from visuals such as sketches in its developed and 'polished' form. As such, there is a growing need for curriculum to be based on literacy, numeracy and 'graphicacy' where 'graphicacy' could be defined as communication in which words or mathematical notion alone are not sufficient. On the other hand, it is equally important for visual-spatial conceptualisation ('visuacy') to be honed and nurtured in a child to complement his

Mohamed Suffian Bin Mohamed Amin (✉)
Singapore, Singapore
e-mail: suffian81@gmail.com

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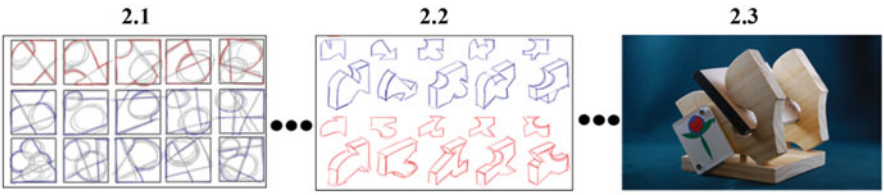

Fig. 6.1 The use of random lines and circles to design and make a notepad holder

competency in 'graphicacy'. 'Visuacy' and 'graphicacy' are important cognitive developmental areas that reside in the domain on non-verbal thought and communication (Cross 2007). In his book, *Designerly Ways of Knowing*, Cross (2007) argues for the inclusion of design in general education based on the following arguments:

- Design develops innate abilities in solving real-world, ill-defined problems.
- Design sustains cognitive development in the concrete/iconic modes of cognition.
- Design offers opportunities for development of a wide range of abilities in non-verbal thought and communication.

Design is an abstract spatial subject that in predominantly intuitive. It is often guided and shaped by the designer's experience and self-thought that eventually results in a 'sketching move' that yields visual triggers spurring more cycles of such design intuition to take place.

In Singapore, Design and Technology (D&T) is a secondary school subject that promotes creativity and critical thinking skills and enhances a child's visual-spatial conceptualisation. The spirit of 'thinking with the hand', one that is clearly emphasised in Design & Technology (D&T), plays a huge role in nurturing our youths to possess dispositions such as risk-taking, critical thinking and inventive thinking. D&T education plays an important role in a child's learning, particularly in areas of cognitive development and non-verbal thought and communication.

Sketching to Design

Learning how to sketch in D&T is a fundamental skill that pupils acquire. Pupils should be able to doodle and sketch freely as means to communicate their design ideas and thoughts effectively in the course of designing. This requires tapping on pupils' implicit acts of questioning, 'self-talk' and internalising self-thought.

The design process, in which pupil designers immerse themselves during D&T lessons, is a multi-directional process involving the different design stages such as research, ideation and development. This requires pupils to go back and forth in the different stages with different experience, learning taking place at each stage.

Kimbell et al. (1996) describe the design process as an interaction between the hand and the head. The act of designing is a conscious process where pupils engage in transforming thoughts and ideas into tangible outcome. To do this, pupils must be able to internalise self-thought, explicate it in terms of sketches or what Cross (2007) refers to as 'iconic mode of representation' and eventually, make decisions to arrive at the outcome (design solution). When doing so, the pupil's mind is engaged is a series of random activity as he makes sense of the 'messiness' that takes place. While one cannot pin-point the exact nature that takes place during this random activity, literature (Cross (2007), Goldschmidt (1991) and Kimbell et al. (1996)) attributed some extent of this to factors such as questioning, 'intuitive' thinking and on-going conversations that take place during designing.

Cross (2011) believes such thinking modes represents an 'intuitive' way of thinking that may be inherently possessed or developed through one's experience. He argued that such way of thinking is specific to designers and the work they do and that other people (e.g. engineers) may be uncomfortable with such way of thinking. Along the same line, Schon (1983) linked the act of designing as a reflective conversation with the situation. It is an interactive process based on a design problem and exploring design solutions. Like Cross (2011), Schon (1983) also related to this implicit activity to intuition, terming such a process as 'reflection-in-action', i.e. the cognitive behaviour that guides 'intuitive' behaviour in designing. These conversations play a pivotal role in the designer's search for a design solution as conversation between the designer and the situation go on back and forth or in Schon's (1983) own term, the situation "talks back" and the designer responding to the situation's 'back-talk'. This infers to the designer being triggered visually, moves by constructing meaning of this visual through patterns and later 'sees' again as he / she makes judgement of the pattern seen earlier.

Design Intuitions and Curriculum Design

Designing and sketching are abstract concepts which reside in the domain of non-verbal thought and communication. The challenge for teachers is to represent these abstract concepts in concrete and tangible forms for pupils to easily understand and manipulate. Due to this, teachers adopt many approaches to teaching designing and sketching. Unlike subjects such as Sciences and Languages where pupils generally learn through activities such as experimenting and role-playing, learning in D&T requires observation skills, dialogue, questioning and more importantly the 'doing bit'. In helping pupils develop elements of the non-verbal mode of cognition, it is essential for D&T teachers to be aware and understand key factors on how development of non-verbal mode of cognition through sketching and drawing skills can be inculcated and explicitly taught in the classroom. Teachers may overlook the essential learning activities within a subject that impacts learning in a powerful and positive way.

In surfacing intuition in design, I will be sharing the findings and design exemplars from a study conducted in 2013 involving 20 Grade 8 students in this chapter. In the study, pupils were given a task to 'design and make a robot animal' for children between 5 and 8 years old as part of an educational programme to increase their awareness on animal cruelty and mistreatment.

Design Context and Activities

The D&T curriculum is predominantly whitespace, leaving the onus on the teacher to plan meaningful design activities for the students. As such, D&T teachers have to constantly be creative in adopting appropriate learning contexts and in the classroom. The subject deals with processes that are mainly ill-defined and dynamic. To teachers, this may pose a challenge as there is no structured and defined way in teaching pupils designing.

Figures 6.2 and 6.3 below show extracts from two pupils' design journals (Pupils A and B, respectively) at the beginning and end of their design activity.

In this activity, pupils were given a photograph of an animal that was pre-selected by the teacher (Exemplars 3.1 and 4.1). They were then required to trace the animal in the photograph (Exemplars 3.2 and 4.2) and subsequently evolve the animal into a 3D robot as a design outcome (Exemplars 3.4 and 4.4).

The choice to design a robot animal was due to the fact that robots are made up of basic shapes and forms such as sphere, cube, cylinder or cone. The underpinning belief in this is that pupils will be able to draw complex objects freely if they are able to break it down into its design primitives, i.e. basic shapes and forms. Such design primitives allow pupils to subconsciously tap on their prior experiences, thus

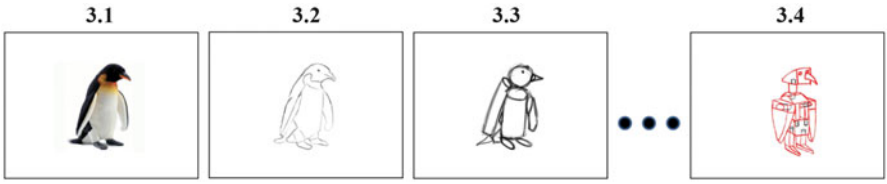

Fig. 6.2 Design process of pupil A for a robot penguin

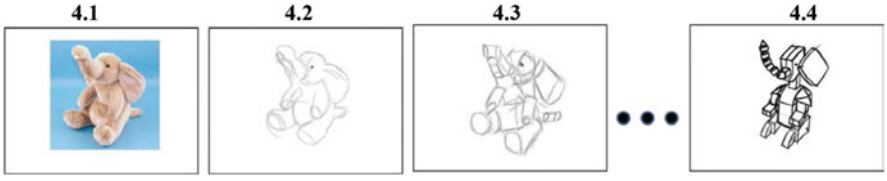

Fig. 6.3 Design process of pupil B for a robot elephant

simplifying their design process. Adding on, the activities will provide pupils with a sound foundation on sketching (as it is based on basic shapes and forms) and will eventually allow them to move on to sketch more complex shapes and forms.

From Figs. 6.2 and 6.3, it can be observed that both pupils struggled with representing the robot animal in 3D initially (Exemplars 3.3 and 4.3). The shapes and forms drawn were out of proportion as the pupils struggle to visualise and convert the 2D representation of the animal into 3D. However, pupils constantly worked on their design sketches by 'sketching and re-sketching' their robot animal. Through this, they developed greater awareness of shapes and form and enhance their visual-spatial conceptualisation, thus improving their sketching skills. At the end of the design activity, pupils were able to come out with a proportionate and appropriate representation of their animal robot that was made up of simple and basic shapes and forms (Exemplars 3.4 and 4.4). It indicated better visual-spatial conceptualisation on the pupils' part as they were able to deconstruct the animal robot down into its basic forms. It further highlighted the importance of a good design choice and context that is appropriate and able to get pupils into the act of designing quickly.

Dialogue-in-Action

Dialogue or self-dialogue plays an important part when pupils design. Self-dialogue helps clarify thinking and provides pupils with a platform to reflect on their work so as to make meaning of them and establish necessary design moves as a way forward.

To 'teach' pupils the skill of 'talking to themselves' requires the teacher to explicitly verbalise his thought process, questions and subsequent design move (in the form of sketches) termed as 'dialogue-in-action'. The teacher would gather the pupils together as he explicitly verbalised his thoughts, questions as he subsequently sketches. Pupils were constantly reminded to be aware of what they were thinking and sketching, in other words to be meta-cognitive of their design actions. Besides that, the teacher also emphasised the importance of drawing quickly or doodling so as to transfer their thoughts visually without missing out any key essential information. By modelling and exemplifying the thought process, pupils in turn would attempt to emulate this 'dialogue-in-action' in the course of their design activities.

Figure 6.4 shows an exemplar of the teacher's design demonstration of 'dialogue-in-action' to pupils as he attempts to ideate a solar powered robot scorpion.

The teacher explicitly verbalised his thoughts through questions such as "can the tip of the scorpion's tail be made of a cone?" In his design move, the teacher quickly sketched out the shape and form of the scorpion's tail to be in the shape and form of a cone (Exemplar 5.3). Subsequently, the teacher would also explicate his thoughts through questions such as, "What about the rest of the tail? Can it be made of spheres? Or what about using cubes?" (Exemplar 5.4). The teacher then sketched out the tail of the scorpion in the shape and form of spheres and cubes. Through this, pupils' ideas would 'grow' quickly as he attempted to explore different variations and possibilities of their robot animal.

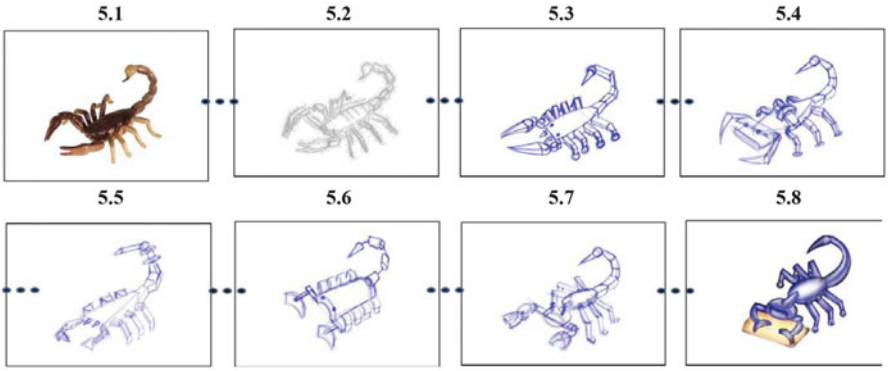

Fig. 6.4 Sample of teacher's demonstration of a robot scorpion

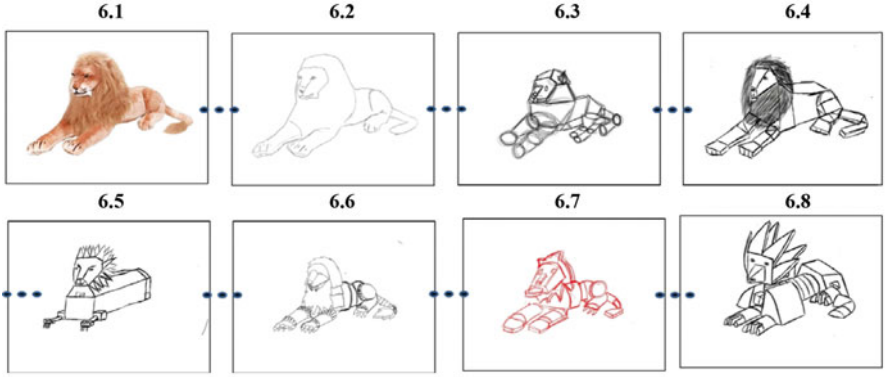

Fig. 6.5 Design process of pupil C for a robot lion

Figures 6.5 and 6.6 show part of the design process of two pupils' design journal (Pupils C and D, respectively).

From the design exemplars of Pupil C and Pupil D, we can easily conclude that both pupils alike struggled initially when ideating on their robot animal (Exemplars 6.3 and 6.4 and Exemplars 7.2, 7.3 and 7.4, respectively). Pupil C struggled in deconstructing the lion into basic shapes and forms. While there was some attempt to use basic shapes (Exemplar 6.4), Pupil C grappled with translating these shapes in its appropriate 3D orientation.

Similarly, Pupil D, in his design of the robot dolphin also had to contend with issues in translating concepts of 2D to 3D representation (Exemplars 7.2 and 7.3). Pupil D also struggled in matching the right shapes and forms to coincide with the different parts of the dolphin (Exemplar 7.4). Both pupils faced difficulty 'stacking' and joining these shapes together to form their desired robot animal.

However, it can be observed that both Pupil C's and Pupil D's designs became clearer and the basic shapes and forms became more apparent later in the design process (Exemplars 6.5–6.8 and Exemplars 7.5–7.8). To add to this, the forms and

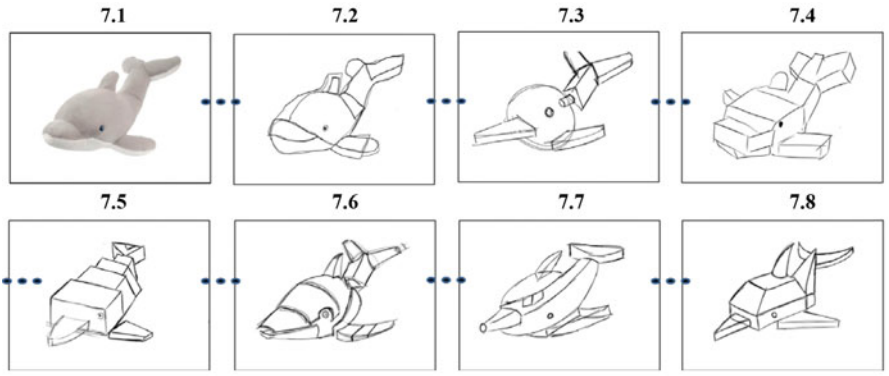

Fig. 6.6 Design process of pupil D for a robot dolphin

orientations were of the right perspective and pupils had no more issues in 'stacking' and joining these basic shapes and forms together to form an animal robot. Both pupils also evolved their design by combining, substituting simple geometric shapes and forms as parts for their animal robot.

In this respect, both pupils would have engaged in 'dialogue-in-action' when going about their design activity. Some implicit activities that could have happened in pupils' brain throughout the design process may involve (but may not be simply limited to) making sense of form and orientation, clarifying thinking, self-argument of the correct shapes and forms to be used for each part of animal, making appropriate decisions for shapes and forms to be used and perhaps, even ensuring the right strokes and angle for different shapes and forms. Ultimately, both pupils were able to represent their 3D robot animal in its appropriate orientation as well as communicate their visual sketches effectively for a third party or a non-designer to understand the essence of their design without having the need for clarification and explanation.

Teacher Co-drawing with Pupils

In addressing pupils' ability to sketch and to communicate their ideas effectively, teachers need to effectively look at their teaching stance to ensure masterful design facilitation. In the course of designing, students often get 'stuck' and faced problems in visualisation or/and idea generation. To overcome this, teachers may co-draw (co-sketch) on their pupils design sheets as a form of a scaffold. Such purposeful actions may open the pupils' minds to alternatives or even, perspectives that may not be 'seen' by pupils. In co-drawing with pupils, there would be a 'rub-off' effect in terms of understanding, visualisation and even motivation of pupils.

Figure 6.7 shows Pupil C experiencing problem in visualising basic shapes in its 3D form and orientation for his robot lion (Exemplars 8.1 and 8.2). In realising this, the teacher intervened (Exemplar 8.3) by drawing crates to help Pupil C improve his visualisation.

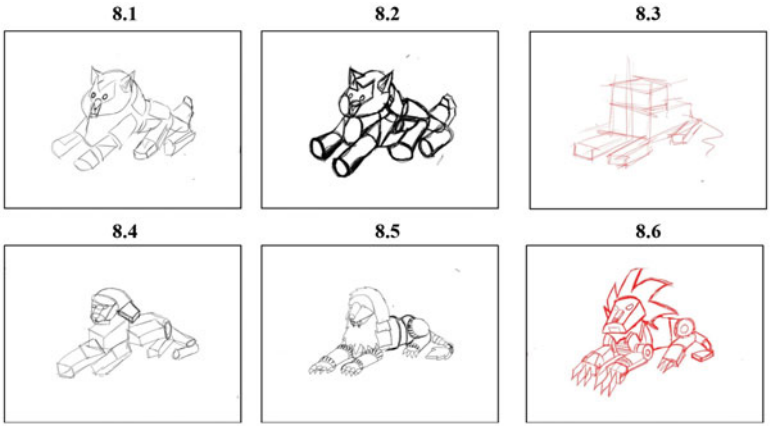

Fig. 6.7 Teacher intervention with pupil C who faced problems visualising basic shapes and orientation in 3D

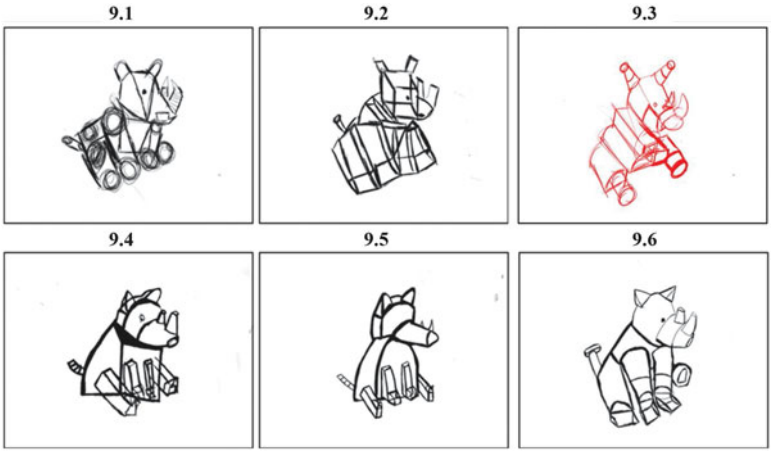

Fig. 6.8 Teacher intervention with pupil E who had poor visualisation and sketching skill

In this case, the teacher intervened by drawing 'crates' (3D boxes) as a guide for the robot lion. With the crate boxes in place, the pupil simply had to ensure that his sketches conformed to the orientation of the crates (drawn by the teacher). In this respect, the teacher had made a timely intervention to address this issue and as can be seen from subsequent sketches, Pupil C had no such issues with orientation and was able to generate more ideas from the point of intervention onwards (Exemplars 8.4–8.6). This shows that by addressing and intervening at the right moment, the teacher is not only able to address the core issue immediately but also propel and motivate Pupil C to explore with more shapes and forms for his robot lion.

Figure 6.8 shows Pupil E having poor visualisation and sketching skill.

From Pupil E's initial sketches, it could be observed that he grappled with the whole concept of 3D sketching as well as visualisation. Pupil E was not able to make sense of the different parts of the rhino, such as the leg, body, horns and the tail (Exemplars 9.1 and 9.2). To address this, the teacher picked up Pupil E's last sketch and together with the pupil doodled and discussed on how improvements could be made from his last sketch (Exemplar 9.3). The teacher also corrected the pupil's initial sketch by sketching the shapes and forms in this correct orientation and replaced some shapes and forms with others to 'open up' pupil's perspective to other different forms and shapes for his robot rhino. In his subsequent design sketches (Exemplars 9.4–9.6), it could be observed that Pupil E was now trying out different shapes and forms for his robot animal with significant improvement in the orientation of the robot rhino.

Conclusion

Facilitating design requires an appropriate design context, modelling and exemplifying the designer's (teacher) thoughts in the form of 'dialogue-in-action' and co-drawing with pupils to address misconceptions in sketching. The examples shared in this chapter provide critical insights on how pupils can develop their visual-spatial conceptualisation by participating in activities that taps on their experiences and intuitions. It also highlights the key role of the teacher, as a masterful facilitator to provide feedback, interventions and support for pupils facing problems when designing.

The exemplars also revealed a strong relationship between learning sketching and pupils' visual-spatial conceptualisation. In this endeavour, it could be observed that the pupils go through three significant stages when learning sketching namely, visualisation, conceptualisation and exploration as illustrated in Fig. 6.9.

These stages are incremental and developmental in nature and indicate pupils' competency level in sketching. Initially, pupils visualise and sketch ideas / objects in 3D (translate 2D sketching to 3D sketching). Upon being successful at this, pupils

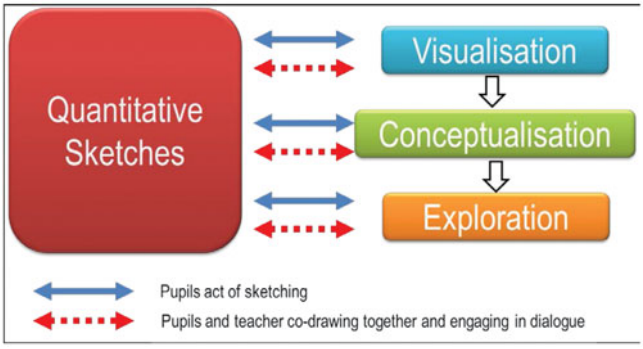

Fig. 6.9 Representation of pupils' learning through sketching

began to conceptualise these ideas/objects in 3D form. Pupils then began to explore with different forms of ideas / objects leading to a creative final outcome. At each level, pupils engage in sketching as well as facilitation process by the teacher that involves dialogue and the teacher co-drawing with pupils. Pupils respond to this by sketching and re-sketching their ideas bringing about greater clarity and visual-spatial conceptualisation with each new sketch.

The exemplars strongly suggest that pupils' visual-spatial conceptualisation improves as the pupils engage in producing quantitative sketches through the design process. With this, it is perhaps reasonable to claim that quality in sketching will surface through quantitative and repeated attempts at this endeavour. The findings are consistent with literature such as 'Dialectic Nature of Sketching' (Goldschmidt 1991) and 'Interaction Between the Hand and the Mind' (Kimbell et al. 1996). It also highlights the value of teaching sketching to pupils, aged 13–16, especially in terms of sustaining cognitive development in the concrete/iconic modes of cognition and development of wide range of abilities in non-verbal thought and communication (Cross 2007).

As such, it is not an understatement to claim that 'teaching' drawing and sketching in the context of designing plays an important role in developing a child's mind, the cognitive development of the child when he is engaged in drawing and sketching. The teaching of sketching and structured scaffolding is able to propel and spur pupils to go beyond their limits and explore beyond their capabilities, thus develop pupils' innate ability in solving ill-defined problems. One can also make reasonable claim that sketching serves as a domain of knowledge; here domain of knowledge may be an understatement to develop a child's mind holistically as nested richly in the scope of a D&T design process that can be applied across many facets of the child's life and activities eventually as a person. This chapter has attempted to highlight key considerations when planning for design activities to surface intuition in design. It has described the conceptualisation and manipulation of 3D objects in space. What of intuitions about space and local environments in and of themselves? These questions are addressed in the next chapter.

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Chapter 7
From Seasons to Cisterns: The Nature of Geographical Intuition

Kenneth Y.T. Lim

Introduction

Geography is essentially a spatial discipline. Much of geography describes the relationship between humans and the environments in which they live. This relationship acts and manifests itself in a diversity of ways, both in terms of the anthropogenic influences on the environment, as well as in terms of the impact of these environments on human culture and habitation.

As an academic discipline, geography is sometimes characterized through the schismatic polarity of physical geography and human geography. Within these, the canonical taxonomy includes – in the case of the former – fields such as geomorphology, tectonics, and hydrology, as well as – in the case of the latter – demographics and urban morphology. In the gray area betwixt the two lie contested waters such as climatology, weathering, and pollution; these fields of study are contested not only in terms of taxonomic classification, but also – as should be evident – in terms of everyday business practice and the body politic of civil society.

The extent to which these classifications are meaningful and the extent to which they are interpreted, fought over, and guarded by their respective proponents and antagonists should not be underestimated. In many universities, the department of earth sciences and (say) the department of urban studies are quite distinct organizational constructs; this suggests that the ways of thinking, knowing, and feeling about what might (for the sake of argument) be termed physical geography and human geography are likewise also distinct.

Continuing this line of argument, it would not be unreasonable to propose that as the earth sciences and physical geography are more akin to the natural sciences in

K.Y.T. Lim (✉)
Centre for Research in Pedagogy and Practice,
National Institute of Education, Singapore, Singapore
e-mail: kenneth.lim@nie.edu.sg

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terms of their ontological structures, the principles which define them are more universal and less culturally bound; in contrast, much understanding in human geography might be argued to be – almost by definition – challenging to decontextualize apart from local cultures.

Consequently, the intuitions pertaining to physical geography might possibly be less culturally dependent than those pertaining to human geography. For example, how a child attempts to understand orogenesis (mountain building), or fluvial morphology, might be argued to similar, regardless of whether that child calls the Pyrenees home, or Brooklyn home. In contrast, the same child from the Pyrenees might seek to make sense of the looming threat of a graying population in quite a different way from his or her counterpart from Brooklyn.

The preceding thought experiment certainly holds potential for research. In the context of the present chapter, however, we would like to suggest that we may have traipsed too readily along the train of thought with insufficient criticality. Specifically, notwithstanding the schism which exists between physical geography and human geography in so many universities worldwide, it behooves us to spend a little time questioning the assumption that such clean breaks – which make sense from an organizational perspective – have equal or similar validity from the perspective of the nature of geographical intuition.

For instance, might it really be valid to propose the argument – as we suggested in a preceding paragraph – that the intuitions pertaining to physical geography might be less culturally dependent than those pertaining to human geography; that is, that how our child from the Pyrenees attempts to understand orogenesis or fluvial morphology would be similar to our child from Brooklyn?

Almost intuitively (pun intended) one might respond in the negative. Even something as apparently incontestable as the cardinal points of the compass as a reference for making sense of one's position in one's local environment is heavily invested with meaning – largely from a Western Occidental perspective; the First Nations of Australia and of the islands of the Pacific, for example, do not find their way – nor define the lay of the land – in terms of a Cartesian grid.

Context matters in geography, both in terms of physical geography and in terms of human geography. Thus, the fields of gray – for example, climatology and pollution – betwixt these two major domains might have much to help us articulate the nature of geographical intuition, rather than just being "an inconvenient truth" (Gore 2006). Geography is – after all – primarily about the relationship between humans and the environments in which they inhabit.

This latter notion of habitation is important to understanding how the contributing authors of this book seek to approach intuition. This is because with the notion of habitation comes the concomitant concept of the lived experience – which is very much bound in sociocultural context (among other parameters). A central thesis of this book has been that it is through the lived experience that intuitions are developed. Further, while the lived experience is firsthand, it can be experienced directly or vicariously.

Gee (2003), for example, has written about the role of what he has termed Projective Identity in game-based learning. Briefly, Gee describes how – in well-designed learning environments – a learner might potentially develop a

Projective Identity as an amalgam which complements both his or her atomic (human) identity and the virtual (avatar) identity, and how such Projective Identities might persist beyond the instantiations of the game and/or the immersive environment to influence values and behaviors in other (nongame) contexts. Gee's thesis thus speaks directly toward the present framing of intuitions as developed through the lived experience, which can therefore include embodied experience in both human- and avatar-based settings. Since intuitions may be thought of as protocognitions developed through embodied experience, geographical intuitions may be potentially thought of as protocognitions about the man–land relationship and systems in earth-sciences. However, much of the latter takes place at scales beyond the human (time and space).

The Nature of Geographical Intuitions

There is a well-known fable of how to boil a frog; the water should be brought slowly to boil, so that the frog becomes accustomed to the gradual increase in temperature and does not jump out of the pot. Alas, it might be argued that what is true of the frog is true also of humans. Many of the phenomena that geographers investigate take place over large spans of scale – both spatial scale and temporal scale. Orogenesis, for example, takes place over thousands of years; these spans of time are of course far greater than the human life span. Likewise, mountain ranges such as the Alps and the Himalayas were formed by the collision of continents, which is at a level of spatial scale far beyond everyday lived experience.

The opportunities for the development of geographical intuition in many aspects of the discipline therefore do not look entirely rosy. The outlook gets worse. To continue with the frog analogy, sometimes the fire beneath the pot gets a little unpredictable and flames up. The temperature of the water in the pot therefore sometimes does not rise steadily, but increases in sudden spurts. This does not happen too regularly, of course, but when it does, the frog does get a little agitated.

Extreme events do not happen very frequently in nature, and when they do, they are notoriously difficult to predict with any accuracy. While extreme events such as hurricanes and earthquakes are unpredictable, they do admittedly represent opportunities for those living in the affected areas to experience the force of (largely) natural events to degrees not within the everyday. For the inhabitants of these areas, these events help calibrate their understandings of the magnitude and frequency which characterize such phenomena. For students of geography, on the other hand, the very unpredictability of such events – not to mention the level of hazard they represent – mitigates against the practicality of conducting field-based studies immediately following these events.

Given the preceding arguments, and with a view to synthesizing the various positional statements so far in this chapter, we have suggested that geographical intuitions are protocognitions about the man–land relationship and those systems in earth-sciences that operate at temporal and spatial scales sensible to humans.

The inherent spatial and systemic nature of many areas of geographical investigation has meant that geographical problems have been challenging to represent meaningfully within the spatial and temporal confines of a classroom. Such representations are important in learning because they form the substrate upon which the embodied experience of learners is built; in turn, continual embodied experience helps learners derive enduring disciplinary understandings through the development of intuition.

Since we consider geographical intuitions as protocognitions about the man–land relationship and those systems in earth-sciences that operate at temporal and spatial scales sensible to humans, and because the discipline of geography foregrounds the man–land relationship, such geographical intuitions are contextually bound and would vary from biome to biome. This stance – that there is a variation of affordances for the development of intuitions from biome to biome – might lead one to the (erroneous) inference that a corollary of the present discussion on geographical intuition might be the prediction of geographical phenomena as they vary across regions.

Simply put, is one aspect of geographical intuition a layperson's attempt at predicting the weather? The present authors would respond to this in the negative; it bears repeating that we do not refer in this book to intuition as a "sixth sense" – that is, something that certain people have and others do not – but as protocognitions (malformed, often incomplete, ways of structuring points of data) that everyone has the capacity to develop over time through his or her respective embodied experience, and which form the substrate for subsequent decision-making.

For example, Rappaport (2009) remarked that "little exists in the literature to specifically address how students understand weather, particularly at the secondary and undergraduate levels." Insightfully, in the context of intuition, he went on to say that "along with formal instruction, young people possess a lifetime of observational experience with the water cycle. They have all seen kettles boiling, bathtubs steaming, and the accumulation of clouds in the sky before a rainstorm… to the instructor, this suite of common examples represents a windfall of opportunity. Any classroom with a window and a thermometer may become a laboratory for the discussion of weather." Critically, though, Rappaport ended this rosy promise with the lament that "personal experience suggests that these connections are *not* being made in many classrooms. Consequently, undergraduates are *unable* to connect theories with actual phenomena" [emphasis added].

The point being made is that while everyone might have the capacity to develop intuitions over time across a range of disciplines, problems arise (from the point of view of designing for learning) in terms of the tacit nature of such intuitions; that there are too few opportunities to make the tacit explicit (so that it can be dialogued about); the fact that they are often overlooked by curriculum designers to begin with (the *tabula rasa* paradigm); that learners may have strongly developed intuitions in one area while poorly developed ones in another; and the degree to which they can sometimes strongly influence attempts within the formal curriculum for structuring learning and cognition.

The example of intuitions concerning the weather is an interesting one, because it is worth asking if it would matter if the question were asked by someone who

might simply be making small talk about the weather, as opposed to someone whose livelihood depended on weather in a more direct way (such as a farmer). The thought experiment is an open-ended one, of course, and it would be probable that – especially in the case of the latter – one would attempt to triangulate one's predictions against a range of sources. At any rate, to adopt a stance consistent with the entirety of the present book – in which we consider intuitions to be the tacit resource which influences behaviors, and which one draws upon to make decisions – the fact that our hypothetical layperson (in the former case) were expressing an opinion about the weather in the context of making small talk, would not fall within the realms of how the authors of this book have been using "intuition."

Instead, geographical intuitions about the weather manifest themselves culturally, such as in the case of Eskimos who have so many different words for snow, and how those in the tropics have a very different understanding of rain/storms than those living in temperate zones. This is because their embodied experiences are different, leading to different protocognitions about meteorology. Their cognitive substrate/schema (Bruner 1966) is different, meaning that the way they attempt to make sense of environments will be different.

To take two contrasting anecdotal examples from the author's personal experience, he once observed a geography lesson in a state-funded school in Singapore in which a Grade 9 student – during a lesson on "Weather and Climate," and in response to a question posed by the teacher – responded that "Singapore does not have any thunderstorms." When asked to explain why this was his view, it became apparent that he had not known that the localized thunderstorms that Singapore experiences because of both convectional and monsoonal rain and squalls on a (almost) daily basis were indeed thunderstorms, having thought of thunderstorms as typhoons and hurricanes (which Singapore does not indeed experience, due to her location just 1° North of the Equator), because those were what seemed to be more emphasized in the textbook. The second example was during the author's undergraduate days in England, and took place one evening within the confines of the college's Junior Common Room: a fellow student opened the door and rushed into the Room remarking "Gosh, it's raining cats and dogs out there." Curious, I first looked out the window, then opened the door, and saw – what I considered to be – a light drizzle.

Such casual utterances may seem out of place in a book about how people learn, and might be too readily dismissed outright in a formal classroom environment – the former because it is factually incorrect, and the latter because it does not reflect use of the jargon appropriate to the discipline. Yet, because we are building the argument that intuitions are critical in understanding how learners structure information into knowledge, and that opportunities for the surfacing of such intuitions from the tacit to the explicit are too few, we would like to suggest that it is these very utterances – and others like them – which teachers and curriculum designers should consider paying more attention to.

In fact, formal descriptions of how man thinks and feels about the local environment are not new Appleton's (1975). Prospect-Refuge theory of landscape appreciation was one of the seminal works and described primitive hunter–gatherer instincts in terms of viewpoints ("prospect"), shelter ("refuge"), and "hazard." He elaborates: "the theory

that aesthetic satisfaction experienced in the contemplation of the landscape stems from the spontaneous perception of landscape features which, in their shapes, colours, spatial arrangements and other visible attributes, act as sign-stimuli indicative of environmental conditions favourable for survival, whether they are really favourable or not" (pp. 269).

Perhaps the most influential thinker on this issue has been the geographer Yi-Fu Tuan. Writing in 1976, Tuan described the concept of *topophilia*, as the study of how the land influences the way one thinks, particularly through the affective bond between people and place (Tuan 1976).

One of the most critical aspects of topophilia – with regard to the present chapter – is Tuan's use of different (spatially defined) lenses through which the dialectical relationship between affect and land might be interrogated. Thus, for example, Tuan considered the city, the suburb, the countryside, and wilderness areas as all imparting distinct affordances to the mediation of topophilia.

With a doff of the hat to Vygotsky (1978), it is also worth considering the extent to which the preceding place-based nouns – city, suburb, countryside, wilderness – are bound deeply in culture and mediated through language. This point is not trivial, and is perhaps best illustrated in the inexact degree of congruence in meaning among the English "country," the French "*pays*," the German "*Land*," and the Latin "*pagus*."

As a thought experiment, if we were to take someone who lived on the plains of France (Fig. 7.1) and someone from an urban metropolis (Fig. 7.2), on to a volcanic island formed as a seamount (Fig. 7.3), and each will attempt to make sense of

Fig. 7.1 The plains of France

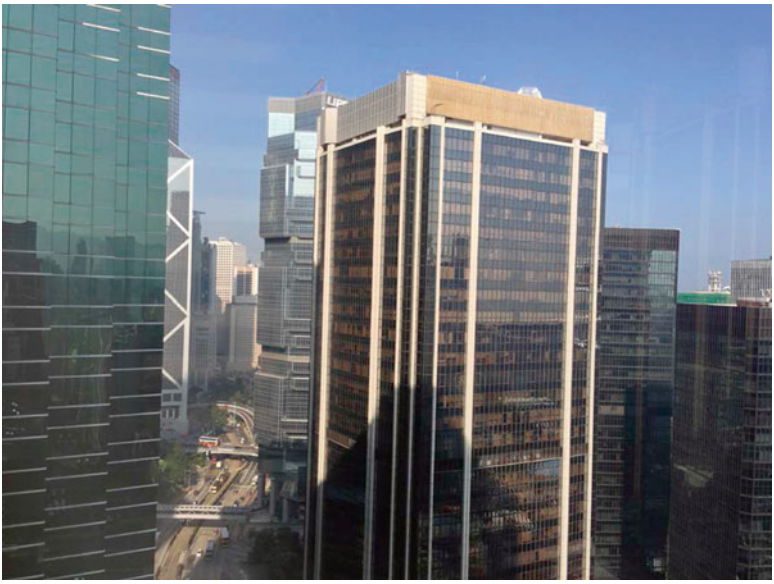

Fig. 7.2 Hong Kong as a metropolis

Fig. 7.3 The caldera at Diamondhead

the (alien) environment in very different ways. This poses the question: What kind of geographical intuitions are developed in an urban setting, as opposed to a more rural one?

In the context of the present chapter, it is respectfully suggested that the trilectic interplay between place, culture, and language define the parameters within which geographical intuitions are nurtured.

To the extent that one of the aims of formal curricula in school is to help novices in the discipline (in the case of this chapter, namely, students of geography) appropriate the epistemology of professionals in the field, enactments of the curriculum are obliged to address the related problems of a schooling experience decontextualized from disciplinary practice, with a consequent lack of authenticity.

Geographical Intuitions and Curriculum Design

The argument that we have been building toward is that from the perspective of a curriculum designer in geography, much of what might constitute a meaningful curriculum for geography education (as constituted along canonical taxonomies established in alignment with Occidental traditions) involves the study and interrogation of events and phenomena – natural and otherwise – which students in general might have limited opportunities to have everyday lived experience thereof. Consequently, if the curriculum is poorly enacted, or if it is being enacted in a particularly resource-poor environment, the learning runs the risk of insufficient authenticity (because of a lack of context), with consequent implications on how enduring the learners' understandings are.

The problematic described in the preceding paragraph can be argued to be particularly pressing in Singapore. There is a well-established and active fraternity of geography teachers in the island-state; this fraternity acts in complement with academically productive members of the geography faculties in two of the country's largest universities. This academically and pedagogically active fraternity in Singapore has resulted in the happy situation in which geography is a popular subject offered to students in secondary schools, and one in which they generally do well during national examinations. However, in the author's professional experience over 22 years dialoguing and interacting with teachers, curriculum designers, and school leaders – including as Chair of the Geography Teachers' Association of Singapore – it might possibly be argued that there is a general consensus that more might be done to design learning environments which results in students having more enduring understanding of geographical phenomena and processes, as opposed to their (often) superficially correct utterances and performances built upon hours of rote learning, drill, and practice.

For instance, a primary problem that curriculum designers in geography apply themselves to, is the understanding of scale – both in terms of space and time (such as, but not limited to, the passage of geologic time). The difficulty of appreciating geomorphological processes as they unfold over space and across time is universal for

many novices to the discipline, and is particularly acute for students in the city-state of Singapore – which has a land area of only 710 km^2 (equivalent to approximately eight times the size of Manhattan, and less than two-thirds the size of Hong Kong).

Not only is Singapore small in area, but it is also low in relief; the island's highest point is 164 m above sea level – the hill is a granitic intrusion and much of the island is geologically alluvial, meaning that it is almost unrelentingly flat. Singapore is a small and low-lying island, which made it all the more surprising when – again in the spirit of sharing anecdotes personal to the author's experience in a variety of classes and lessons – he once heard a middle-school student remark to the teacher that "Singapore is high above sea level." The teacher was alert and sufficiently adept to respond to this utterance in a manner which did not put down the student (who had obviously volunteered it in good faith) and it was only after a good few minutes of repartee that the teacher successfully deconstructed the student's belief to be down to the fact that Singapore – in the latter's own personal experience at least – does not suffer from frequent or serious floods.

Lived experience therefore serves to calibrate one's frames of reference, in turn, one's frames of reference define the general boundaries within which intuitions develop.

When Intuitions Pose Problems

Intuitions can therefore be barriers to what McTighe and Wiggins (1998) have termed "enduring understanding," and we present a few examples as to just how powerful these barriers can be. Perhaps one of the most well-known is a consequence of the general difficulty at representing the geoidal form of our planet on a two-dimensional surface. Entire tomes have been written on the subject, but suffice here to consider the puzzle of how the shortest distance between two points on the planet's surface is represented on a plane. A novice in geography would not easily grasp the representation of the answer as an arc on the plane, and not a straight line. We consider the cognitive dissonance initially caused by the "puzzle" of the Great Circle (Fig. 7.4) to be one of the most intelligible ways in which to introduce not only the notion of geographical intuition, but also that of the potential power that intuition can exert on learning.

The example also helps make the distinction between misconceptions and intuitions: it is clear that the novice initially has a misconception, but that is not what is resulting in his or her incorrect response (the straight line) – we are interested instead in asking what lies *behind* the misconception.

Taking again the example of the remark that "Singapore is high above sea level" – while this is clearly a misconception – what we suggest should be just as intriguing in thinking about learning is how the tacit intuitions which are implied by this explicit utterance go on to frame other occasions when the same student attempts to make sense of his or her textbook and learning experiences in the formal

Fig. 7.4 Arc of a Great Circle

curriculum, say, when the student approaches the topic of the tectonic forces behind mountain-building.

Further, our thesis of the disciplinarity of intuitions implies that the ways in which intuitions manifest themselves, and the ways in which curriculum designers might mediate them, are potentially diverse. Apart from the disciplinary-specific problematic of dimensionality and scale, geography teachers also face problems of bridging the relatively decontextualized renditions from much curricular material to more authentic and enduring understandings. Since 2009, the author has been working closely with the Ministry of Education in Singapore, and teachers from a variety of primary and secondary schools there, to use an immersive environment to nurture map literacy, from a first-principle perspective which foregrounds the development of intuition about the language of maps.

This approach contrasts with the more traditional post hoc strategy of map reading (as opposed to map literacy) in which students are required to memorize the symbolic language of maps without sufficient care being given to why exactly the symbols are the way they are in the first place. For example, learning activities have been designed in which students – through their operation as avatars exploring within a true-scale immersive environment – manually generate terrain plots on graph paper of their relative position and altitude in an incremental, dot-by-dot manner. As Fig. 7.5 illustrates, by literally connecting the dots on their plots, they see the contour map appearing before their eyes, by their own hand, and depicting a landscape that they themselves are exploring in real time. By doing so, they are also developing the epistemological understandings of professional geographers, as they seek to transpose their two-dimensional paper-based renditions vis-à-vis the three-dimensional landscapes that their minds are stitching.

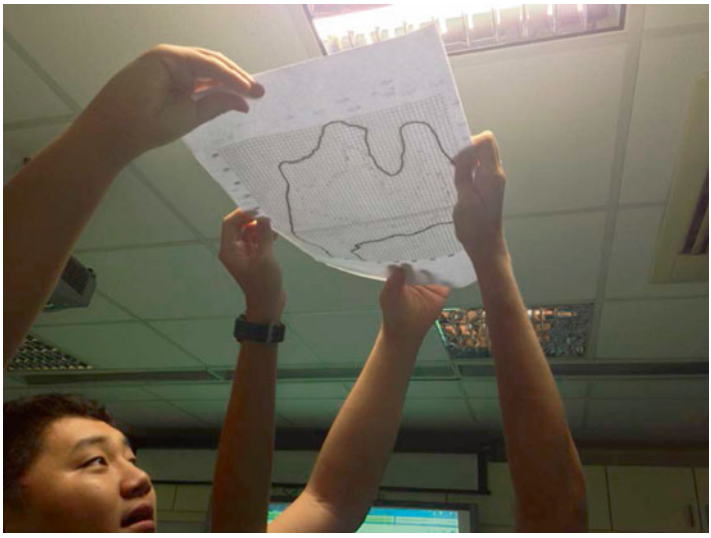

Fig. 7.5 First principles in map literacy

This approach of going back to first principles in map literacy does take more time than what might be construed as the more pragmatic approach of simply providing examples of contour maps for the students to practice on. The teachers who participate in the program are willing to set aside the time because they have invariably found that the opportunity cost is worth paying, as the approach results in the students being able to apply themselves more flexibly to map interpretation – since they have first principle understanding – as opposed to merely having a pointilistic familiarity with landscape. The potential problems associated with the latter are illustrated in the following transcript, which depicts a protocol of interaction between the present author and three students from a state-funded middle school in Singapore. The learning activity was for the students – in their groups – to generate a contour map pertaining to a drainage basins which they had terraformed for themselves during the preceding lesson within an immersive environment, with each basin measuring a true-scale 120 m by 30 m. This particular group of students was chosen for a focus group discussion because they experienced a particular difficulty as they attempted to complete the task.

Specifically, the task was designed such that each basin had a horizontal plane bisecting its entirety, and – because this plane could be adjusted up and down (along the z-axis) – the students could use a plan view of the interaction of the plane within the basin to transpose the three-dimensional topography of the basin into a two-dimensional contour plot.

The particular difficulty that this group of students faced as they attempted to generate their contour map of the basin, which had been formed by their own hand, should become clear as the transcript of the exchange between teacher and

students unfolds. Particular note should be taken of the student's repeated use of the words "normal" and "normally"; as one reads the transcript, it is worth asking oneself just what it is that might have given rise to a sense of the "normal" in the students' understandings (this theme is picked up by Yin in the subsequent chapter).

S1: So… you want us to talk about the problems that we all faced?
T: Yes, that would be a good start.
S1: Basically, what I think – judging by what my whole group thinks – is that normally in a normal geography textbook, right, what they will normally give is that in the inside – the circle inside – is normally the trigonometry, the triangle…
T: … Trig point or spot height
S1: … Ya, which is the highest point. Ya, so, especially normally, what we will think is that the inside one is most probably the highest one. So when I actually plotted the graph, I suspected it to when I draw it, it's not, I wouldn't draw it outside, I would more draw it, draw the shape inside
T: So, this is where I start not understanding you. So the basin was this (makes a basin shape with two hands) this is the basin right, it wasn't a hill, right, we were doing a basin, what were you…
S1: For example this is like, for example it's like that, what we all would normally do is I would draw here…
T: Oh you draw from the inside out
S1: Ya so instead I draw
T: Ok you were drawing from the inside out
S1: Ahhhh (in affirmation)
T: Ok you were drawing from the inside out and then, but there was confusion because the (contour) plane was coming from the bottom up
S1: Ya
T: Ya ok I understand. But what did your thing look like originally?
S2: He did it on this side
S1: Ya
T: Oh he only drew, ok, ok, ya because I heard Miss Lim
S2: She said he was only drawing the river, like the water part
T: Ya because she probably didn't realize what you were doing, because I also would not have realized what you were doing until you just explained to me what you were doing. If I just see this (conceals part of the drawing) I would also have thought you were just drawing the river channel, ah?
S1: Mmm
T: But actually what you were trying to do is you were trying to draw the bank, right? But actually just from this alone without any explanation it looks as though you were drawing a channel. So then, ya, that's when you all said that Miss Lim said that it was wrong. Then
S1: Then we all erased. Ya then we draw it, but now we draw it we still draw it inside out. At first it was just two boxes (grid quadrants). We expand it but we still draw it inside out. Then she said it was wrong. *So we actually didn't believe* (emphasis added). We didn't believe, serious.

S3: Ya, we thought we were right.
S1: Because we thought we were right. Then after that we went and checked with the other groups
T: How did she know that you were wrong, ah?
S2: I think she looked at both of our work
S1: Ya, then after that she said that we were correct
S2: No! She didn't say! She said that to wait for… then after that, I don't know
T: But on the surface it would have looked the same, because on the surface… unless she was paying close attention to your figures, which I don't think at that point of time maybe you weren't writing your figures. Ok supposing, just supposing you guys did it correctly then yours would have looked something like this, right? Going from the inside out, because the (contour) plane was getting higher and higher. Now if you guys were doing it wrongly, you would have been… see, I can't even do it, er, I don't know how, er. Initially they would have just seen the narrow thing. Unless, unless they were drawing not what their eyes told them. Ar, maybe, ok, maybe, maybe you, let's say this is the first, the first one that everybody draws is like this, right? Ok? Now, so, then when the contour plane went up, actually, you drew… ah, I know what you
S1: Ya we were
T: You were squeezing it within
S1: Yeah
S2: Ah
T: So your eye was… you were drawing not what your eyes tell you but you were drawing what your brain was telling you to do rather than what your eye was telling you to do. Because your brain was basing it on what they know of the textbook. Ya ya ya, ya I understand.
S1: Mmm
T: Ok I understand. Thanks.
S1: And so, that's the problem

Indeed, problems afford excellent opportunities for intuitions to be made more explicit, to be interrogated, and – ultimately – to be refined and codified as knowledge. As the finale to the nineteenth season of the popular BBC television program *TopGear*, the producers set the episode in East Africa, posing the presenters with the task of finding the (ostensibly true) source of the river Nile. Apart from a couple of hours' worth of entertaining television in which three preloved estate cars were driven to destruction a *wadi*, the episode also surfaced such geographical gems such as

> what have we got here? we've got bedrock, we've got the ground has sunk down [*sic*], indicating the presence of a spring, in my mind;

set off by the wonderfully contradictory tension – all thrown in for good dramatic effect, admittedly – between

> right, trees, trees all going along a little valley, that can only mean – river;

and

> that is a valley, i'm not heading down into there. The source of the Nile isn't going to be in a valley.

Beyond the world of broadcast media, tensions in geographical intuition can potentially play out in classrooms and other learning environments – indeed the challenge is for curriculum developers and teachers to deliberately design for opportunities for dissonance, during which students – through their decisions, behaviors and utterances – might manifest their own evolving intuitions so that they can be dialogued about.

As an example, in his work with immersive environments in the learning of geography with secondary schools in Singapore, one of the curriculum units which the present author has codeveloped with teachers is one in which students – in their groups of, say, four – are given plots of land in an immersive environment; these plots of land are the same true-to-real-life-scale plots referred to in the preceding example. Within their assigned plot, they are tasked to terraform the land to form a drainage basin of their own design. These basins can then be visited within the environment by their peers and teachers – as per a "regular" field-based activity – and each group has the opportunity to explain and defend their respective designed landscape.

During one such enactment of this curricular unit on geomorphology and hydrology, a group of students terraformed a meandering channel in the middle course, and an ox-bow lake. Much of Singapore's natural drainage has been canalized during the course of her urban development, and there are no ox-bow lakes in Singapore. Such fluvial features are, however, described and explained in the geography textbooks in Singapore. The group of students who made the extra effort to terraform an ox-bow lake along their meandering channel were clearly trying to apply what they had studied about from their texts, to the practical exercise before them that day. Such initiative is certainly laudable.

What is of particular relevance to the present chapter is that the teacher was sufficiently alert to realize that there was a problem in the positioning of the ox-bow lake with respect to the meandering channel as a whole – Fig. 7.6 shows that the students had in fact terraformed the ox-bow lake at one of the apices of the meandering channel, whereas ox-bow lakes are more likely to be formed in between apices (because of erosion of the outer banks and deposition on the slip-off slopes).

The students had therefore remembered that ox-bow lakes may occur in a meandering channel, but they had not fully understood the hydrological processes behind their formation. We would like to suggest that at least part of the reason might be attributable to the synthetic nature of Singapore's urban landscape, which – in turn – affords insufficient opportunities for Singaporeans in general, and children in particular, to develop intuitive understandings about processes in the natural environment. By itself, this would be an unfortunate situation, but not too much of a problem; it is only because these same children are later expected to demonstrate competency in articulating their understandings of these very processes during national examinations, that the disjunct becomes particularly dire.

Fig. 7.6 An ox-bow lake as a teachable moment

Geography All Around Us – Opportunities for Developing Intuitions

It is acknowledged that Singapore is just one of many urban metropolises across the world. Again, we would like to suggest that by itself, urbanization is not the root of the essential problematic that constitutes the thesis of this chapter. However, Manhattan, Tokyo, Hong Kong, Rio – among so many others – have one critical element which Singapore does not, namely, a readily accessible hinterland. Children growing up in these great metropolises have many opportunities – through their interactions with extended family, at school, and with the mass- and social-media – to develop understandings that there exists a wider "world out there" beyond the environs which they are immediately familiar with. In fact, in the case of Hong Kong – for example – topographical variation, natural climatic hazard, the geopolitics of regions, and transboundary pollution are all inherently part of the daily lived experience of children.

Not only does Singapore not have a hinterland readily intelligible and/or accessible to children, the environments which form the local lived experiences of these same children are largely synthetic, in that they are facsimilies of the natural. Ironically, this is in part because Singapore's urban planners have been acutely aware of the constraints on land-use, and also because Singapore has marketed itself as a "clean and green" place in which to live. Thus, in a deliberate effort to not fall into the stereotype of a concrete jungle, urban planning in Singapore has instead attempted to bring the (rain)forest into the cityscape. Not only has this resulted in the import and pervasiveness of floral species which are not endemic to her shores

Fig. 7.7 Very clean and very green – Bishan Park in Singapore

(as is the case in other urban areas across the world) but the efforts go as far as importing sand from neighboring Indonesia for the beaches, and the creation – at the cost of US$ 60 million – of an artificial river channel which (conveniently) runs alongside a trunk road without bisecting or undercutting its embankments (see Fig. 7.7). It should be clear that these (and other) synthetic facsimilies of natural environments in Singapore do not bode well for the development of accurate intuitions about geomorphological processes among children.

Indeed, Kong (1999, 2000) has argued that children and adolescents in highly urbanized Singapore view nature as something which is orderly and well-maintained. She continues that this rather limited perception arises from the fact that nature is

> a 'waste of time." All the teenage members of the school group acknowledged that nature was not very much a part of their consciousness. When bored and thinking about places to visit and what things to do, the tendency was not to think of activities associated with nature. When thoughts about the natural world did surface in their minds, it was often in the context of school work, for example, their geography lessons, during which nature was more about conceptual issues and scientific processes than everyday environments of potential fun and enjoyment. (Kong, 1999:3)

The phrase "a waste of time" as remarked upon by Kong is interesting, not least because time – or more specifically, one's sense of the passage thereof – is noted by Tuan (1977) as shaping topophilia, at both the scale of the individual as well as that of the community. That nature might be considered "a waste of time" by children and adolescents in Singapore suggests that there are indeed few opportunities – either engineered by others, or by they themselves – for the development of geographical intuition.

Fig. 7.8 Keeping it clean – flushing a cistern

Kong's observations are therefore important because it is our considered position that such "everyday environments of potential fun and enjoyment" constitute the substrate upon intuitions about geography – intuitions about the nature of the man–land relationship – are formed and developed. Such intuitions, in turn, shape geographical ways of knowing, and are thus critical to informing how novice geographers (such as students in school) approach and understand the world.

It has been the intent of this chapter to advance the thesis that – at least with respect to the relationship between humans and the natural environment, and the way this relationship is approached in the formal curriculum – alignment between the assessment of children and their day-to-day lived experience is critical to developing enduring understanding beyond rudimentary textbook recitation. We have suggested that an overlooked element of this alignment has been the role that intuitions about geography play in shaping such understanding, and how these intuitions can sometimes be very powerful in lensing understanding either accurately or inaccurately. The challenge – from the point of view of curriculum designers (who are, by definition, disciplinary experts) – is in reminding ourselves of just how subliminal some of these day-to-day lived experiences might be.

Take the act of flushing a water-cistern, as depicted in Fig. 7.8; for too many among us, we flush, we (may or may not) take the briefest of glances to ensure that the cistern is left clean for the next user, and then we walk away. If we were to be asked – even immediately after flushing – "what pattern of movement did the water take as it flushed down the cistern," I daresay we would be hard-pressed to respond. Far be it for this chapter to give the game away – suffice to say that one's response to that question might potentially permit one to subsequently make connections between such undeniably geographical concepts such as latitude, the rotation of the planet, and Coriolis force.

But then again, perhaps not. Who is to pronounce with any certainty? The point simply being that a multitude of routine experiences iterated over time, can potentially

lead to the shaping of how one thinks of and seeks to understand the local environment. Sometimes, the variation in these iterative experiences is small, while at others it is not. As a final example, consider the diurnal cycle, and how this cycle is experienced by someone living at the equator, as opposed to someone living at a higher latitude.

In 2014, the shortest days in Singapore will fall during the Southern solstice, between the 18th and 24th of December. During these 7 days, Singaporeans will only be able to enjoy 12 h, 3 min, and 2 s between sunrise and sunset. Contrast this with the Northern solstice in 2015 as experienced in Singapore during the 19th to the 24th of June, when the days will be 12 h, 11 min, and 48 s long, before giving way to night. This represents a variation of a little over 8 min, experienced over 12 months – it is extremely unlikely anyone in Singapore would be able to notice this without technological augmentation. Variations between the length of day and night obviously manifest themselves in a much more explicit manner with increasing latitude. This, together with the associated variation in other climatic variables, might lead someone living at higher latitudes to more readily intuit that temporal patterns operate at different scales – that there are patterns within patterns; day and night overlay themselves upon spring, summer, autumn, and winter. The result might feasibly be more nuanced intuitions (not necessarily with completely accurate *understanding*) of one's "place in the world."

For a chapter ostensibly devoted to geography, the theme of time has curiously loomed large. Consider – in closing – the temporal variation of sunset over the span of 12 months. In temperate latitudes, shorter days are a sure sign of the onset of winter; but it might come as a surprise that sunset varies even 1° north of the equator, too. In 2014 in Singapore, sunset will be earliest a month after the Southward equinox, between the 30th of October and the 11th of November, when it will be at 6:50 pm; in 2015 sunset will be latest as the Northward equinox approaches, between the 5th and the 22nd of February, at 7:21 pm. Unlike the earlier example with the solstices, a difference of half an hour between sunsets might be more feasibly noticeable to some (especially, of course, with the aid of time-keeping technologies). Might this point of trivia perhaps indicate that Singapore might not be as lukewarm a substrate for the development of geographical intuitions as much of this chapter has suggested? If the person in question is observant, then – yes – perhaps so. And then again, somewhat akin to the situation of the hapless frog in the pot, one remembers that living at the equator, the days and nights are relentlessly equal in length, regardless of the time of year; in the case of those particular dates, the days are 12 h, 4 min long. The diurnal cycle does not vary significantly in Singapore, after all.

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Chapter 8
Second Language Intuition: Native Language and Linguistic Universals

Bin Yin

Introduction

Suppose an English speaker is asked which of the following sentences is grammatical. These sentences differ with respect to the ordering of the adverbs preceding the prepositional phrase (into the valley):

(a) The helicopter flew straight on through into the valley.
(b) The helicopter flew straight through on into the valley.
(c) The helicopter flew on straight through into the valley.
(d) The helicopter flew on through straight into the valley.

(Stringer et al. 2011)

It is unlikely that anyone has actually encountered any of these sentences before – while the number of words in a language is more or less finite, the number of sentences a language can generate from its lexicon and grammar is infinite. Yet, native speakers intuitively know that sentence *a* sounds grammatical and the rest ungrammatical. English permits multiple modifiers for a prepositional phrase and there is a fixed (universal) hierarchy that speakers have access to, even though they are not aware of it.

What about someone learning English but whose first language (e.g., Chinese, Korean, Japanese, Turkish, and Arabic) lacks the stacking of multiple modifiers? Would they be able to make the correct judgment about the grammaticality of the English sentences in a–d? If a Second Language learner is permanently constrained by the properties of his/her native language, then the answer would be no. If, however, we allow for the possibility that Second Language learners may also be able to access the kind of knowledge available to native speakers, then we may have

B. Yin (✉)
National Institute of Education, Singapore, Singapore
e-mail: bin.yin@nie.edu.sg

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a different answer. This chapter explores Second Language learners' linguistic intuition from these two types of knowledge sources: native language and linguistic universals.

First Language Acquisition

There is largely a consensus that children do not come to the language learning task with a Blank Slate (e.g., Crain 1991). Rather, they are equipped with certain innate knowledge about what all human languages should look like. Concrete linguistic experience (exposure to the child's native language) fine-tunes and changes that innate knowledge and the child then loses some of the linguistic sensitivity he/she was born with. That is to say, children are born with linguistic universals but their knowledge becomes language-specific as a function of experience. A most convincing argument comes from research showing that while infants can discriminate a universal set of phonetic contrasts (Werker et al. 1981), adults are generally more restricted in only being able to perceive sound differences that are relevant in their native language (Gerken 2006; Werker and Tees 2002). In Werker et al. (1981), infants learning English were shown to be able to discriminate non-English (Hindi) sound contrasts (e.g., the retroflex vs. dental distinction /ṭa/ – /ta/) without any prior experience with Hindi, whereas English-speaking adults were unable to do so even with relevant training. In syntax too, children have shown remarkable linguistic sensitivity without prior experience. Crain (1991) reviews a series of empirical research that lends support to the hypothesis that "…linguistic knowledge of considerable complexity emerges in child grammars without decisive evidence from experience" (p. 611). A classic example involves the contrast seen in this pair of English sentences: "Guess who they want to see" versus "Guess who they want to stay" (O'Grady 2008). While the former can be contracted to "Guess who they *wanna* see," the latter cannot. "Guess who they *wanna* stay," is ungrammatical. In generative linguistics, this contrast (in terms of the (un)availability of *wanna* contraction) is due to the very theoretical construct of case-marked invisible traces (e.g., Jaeggli 1980) which would seem impossible to deduce from a young child's linguistic experience. Hence, their demonstration of such knowledge (e.g., Thornton 1990) must be attributed to something innate. Such innate, universal linguistic knowledge can be described as a form of linguistic intuition.

Second Language Acquisition

Unlike children, learners of a Second Language come to the learning task with a (usually) fully developed language system already in place. An important characteristic of the linguistic system of a Second Language learner is the existence of traces from his/her native language. Such an influence (termed "transfer" (Gass and

Selinker 2008)) is manifested in the learning of various areas of grammar including phonology (e.g., Brown 2000; Broselow 1988), morphology (e.g., Lardiere 1995, 2000), syntax (e.g., Hawkins and Chan 1997), and semantics (e.g., Gabriele 2009; Yin and Kaiser 2011). When the relevant linguistic properties in the L1 diverge from those in the L2, transfer may result in nonnative-like representations of the Second Language. The effect of such transfer could be either temporary, existing in the initial stage of language acquisition (e.g., White 2003) or permanent, extending to the very end state of the learning process (e.g., Sorace 1993).

While transfer from the native language is well-documented and forms a very important part of Second Language theorizing, it is observed that Second Language learners' linguistic system (or "interlanguage" (Selinker 1972)) is also governed by "universal forces" that underlie language acquisition in general. Depending on researchers' theoretical orientation, such universals could be the kind of domain-specific (i.e., linguistic) knowledge known to govern child language acquisition (e.g., White 2003; Hawkins 2001) or it could be part of domain-general, cognitive abilities (e.g., O'Grady 2008).

The linguistic intuition of a Second Language learner then can come from either his/her native language, or linguistic universals, or perhaps the interaction of both (e.g., Weinberger 1996). For the rest of the chapter, I review in more detail research showing the influence of native language properties and effects of universal forces in shaping Second Language learners' knowledge system.

Native Language Effects in Second Language Acquisition

The Second Language acquisition literature has abundant evidence showing transfer effects from native language properties. It is beyond the scope of the present chapter to present a comprehensive review of all the transfer phenomena. I will only review some studies/models related to the acquisition of phonology and syntax since they are considered to be the two pillar branches in modern linguistics.

It is perhaps fair to say that phonology is the area where it is most noticeable when transfer takes place. It is generally hypothesized that beyond a certain age, acquiring the Second Language phonology in a native-like fashion is very difficult, hence the attested foreign accent phenomena (Hawkins and Lozano 2006). Several L2 phonology theories including the Speech Learning Model (Flege 1995) and Perceptual Assimilation Model (Best 1995) are directly based on the premise that native language shapes how the learner perceives the L2. For example, the Perceptual Assimilation Model posits that L2 sounds are assimilated into L1 categories based on similarities, and that the difficulty of L2 sounds is based on their level of perceived similarity to L1. In terms of research evidence, Brown (2000) found that if representations of features are absent in the first language, then it is difficult to acquire sounds in a Second Language that rely on those very features. For example, in both Japanese and Mandarin Chinese, the sounds of [l] and [r] are not contrastive, unlike in English where they are. On the surface then, Japanese speakers and

Mandarin speakers would be on the same footing so far as their ability to distinguish these two sounds in English is concerned. In an auditory discrimination task in which participants hear two English stimuli in a pair (e.g., "rip/lip" or "lip/lip") and judge if they are the same or different, Japanese speakers were found to be unable to distinguish stimuli pairs involving the [l] and [r] contrast. (The lack of differentiation between the two sounds is also known as *lambdacism*.) On the other hand, Mandarin Chinese speakers performed as accurately as the native English-speaking controls. The reason, as offered in Brown (2000) is that even though on the level of sound segments, Mandarin does not distinguish [l] and [r], the language does have the feature *coronal* elsewhere in its phonological inventory. Feature is a smaller phonological unit than sound segments. Japanese phonology does not contain the *coronal* feature anywhere in its system. It is precisely the *coronal* feature that distinguishes [l] and [r] in English. The difference between Japanese and Mandarin Chinese on the level of phonological features then explains the differential performance in Brown (2000)'s study. Besides features and segments, native language influence is also seen on the level of syllables. Broselow (1983), for example, discusses the case of Arabic speakers inserting vowels between consonants in English as a result of phonetic constraints in Arabic. For instance, Egyptian Arabic speakers would pronounce the English word *floor* as *filoor*, inserting a vowel /i/ between consonants /f/ and /l/. The reason is that Arabic does not permit consonant clusters (two or more consonants occurring together). In this case, it is the knowledge relating to syllabification that is transferred from the native language to the Second Language. Insertion of a vowel between consonants is a phonological process called *epenthesis*. Nativized varieties of English make use of this process as well to simplify consonant clusters. Singapore English speakers, for instance, would sometimes pronounce *lisps* as [lipsəs], a result that involves the interaction of epenthesis and other phonological processes (Anttila et al. 2008).

In syntax too, there is plenty of evidence that first language leaves traces on the learners' Second Language system. For example, in French, the adverb (*souvent* "often") is placed to the right of the main verb (*regarde* "watches"), an order which as the gloss shows, is ungrammatical in English:

Marie	regarde	souvent	la télévision
Mary	watches	often	television

This difference between French and English is due to a syntactic operation called V (Verb) to I (Inflection) movement. French is analyzed to have this operation (the verb moved to a position before the adverb) and English does not (Pollock 1989). White (1991) investigated L1 French/L2 English students' acquisition of this word order difference. It was found that the French word order persisted in the L2 English system of these students (but that instruction helped to some extent). Besides word order, surface morphology is another area where L1 influence is easily manifested. For instance, English has surface tense (e.g., John walked in the park) and agreement morphology (John likes apples) whereas Chinese does not. Lardiere (2000) examined an otherwise proficient English user with Mandarin as her first language

and found that the speaker, despite having lived in the USA for 10 years, still frequently omitted tense and agreement morphemes in her L2 English production. The absence is at least partially due to the properties of the first language – the impoverished tense/agreement morphology system in Chinese. Turkish, on the other hand, does have a rich tense and agreement paradigm but the language lacks articles (e.g., "the" as in *the apple*). Research has shown that Turkish speakers learning English show greater consistency in providing tense and agreement morphology than they do in supplying articles, once again suggesting influence of first language properties. The interpretation of reflexive pronouns is yet another area of syntax where native language properties manifest themselves in the Second Language system. In English, a reflexive pronoun such as *himself* can only refer to an element in the sentence that is not too far away. For example, in "John thinks that Bill trusts himself," the word *himself* can only refer to *Bill*, but not to *John*. In other words, English requires *local* antecedents for reflexive pronouns. In the Chinese and Japanese equivalents of the earlier sentence however, it is possible for the reflexive pronouns (*ziji* in Chinese and *jibun* in Japanese) to refer to an element further away in the sentence (that is, *John*). In other words, Chinese and Japanese permit *long-distance* antecedents for their reflexive pronouns. Given the difference between English, on the one hand, and Chinese and Japanese, on the other, it is perhaps not surprising that Yuan (1998)'s study found that Japanese speakers performed better than English speakers in acquiring the referential properties of *ziji* in Chinese.

Linguistic Universals in Second Language Acquisition

Besides first language influence, linguistic universals play an important part in the theorizing of Second Language acquisition. The basic tenet is that there are universal factors applicable to all languages and these factors influence both first language and Second Language acquisition. Evidence in support of such arguments usually comes from linguistic patterns that emerge out of the acquisition process independent of the properties of the native and target languages. The emergence of such patterns then is argued to be the result of linguistic universals. Below, I discuss in more detail acquisition models and research findings touching on the role of linguistic universals in Second Language acquisition.

A very important notion relevant to Universalists' work in characterizing Second Language phonology is that of *markedness*, which concerns universal preferences for certain linguistic forms or features. For instance, open syllables are universally preferred over closed syllables; oral vowels are preferred over nasalized vowels; voiceless obstruents (consonants formed by the obstruction of airflow) are preferred over voiced obstruents. The preferred member in the pair is considered *unmarked* whereas the less preferred member is considered *marked*.

With echoes in Lim's chapter on Geography, the unmarked linguistic features are "…in some definable way, simpler, more basic and more *natural* than the other member of the [binary] opposition" (Eckman 2008: 96; emphasis added). The

Markedness Differential Hypothesis (MDH) by Eckman (1977) is based on such a linguistic understanding. It posits that sounds in a Second Language are difficult not just because they are different from those in the learners' first language but also because they are more marked. Less marked sounds, even if also absent from the learners' first language, are easier to acquire. Studies that lend support to such hypothesis include Moulton (1962) on the acquisition of voice contrasts by English and German speakers, Anderson (1987) on the learning of onset and coda clusters in English by subjects from different language backgrounds, Carlisle (1991) on Spanish speakers' production of complex onsets in English, and Broselow et al. (1998) on Mandarin speakers' strategies in simplifying syllable codas in English. For instance, Broselow et al. (1998) found that two strategies used by the participants (making the final sound voiceless and maximizing the number of bisyllabic forms in the output) cannot be obviously motivated by properties from either Mandarin (the native language) or English (the target language). The authors argue that the two effects result from universal markedness constraints present in all grammars even though they are not obviously present in the native language.

The role of linguistic universals is even more widely discussed and debated in the acquisition of Second Language syntax. The specific theoretical question that L2 syntax research directly or indirectly addresses is whether L2 learners can access Universal Grammar (UG) defined as "the system of principles, conditions, and rules that are elements or properties of all human languages" (Chomsky 1975: 29). Views range from full access to universal grammar for L2 learners (e.g., Epistein et al. 1996; Flynn 1996; Schwartz and Sprouse 1996; Prévost and White 1999, 2000, among others), to those who consider UG access is restricted but still available to L2 learners (e.g., Smith and Tsimpli 1995; Hawkins and Chan 1997, among others) and finally to those who reject the implication of UG in Second Language Acquisition (SLA) altogether (e.g., Bley-Vroman 1989; Clahsen and Felser 2006).

Foremost among the evidence showing UG implication in SLA comes from the Poverty of Stimulus (POS) situations where the L2 property is neither derivable from the learner's first language nor inferable from the L2 input (Hawkins 2001). Indeed, some researchers claim that only such phenomena can provide unambiguous and incontrovertible evidence for the mediation of UG in SLA (e.g., Dekydtspotter et al. 1997; Dekydtspoter and Sprouse 2000). Strong evidence in support of this line of work comes from the demonstrated L2 sensitivity to certain structural violations in learners whose first language does not instantiate a kind of syntactic operation (wh-movement) but the structural violation in question depends on the existence of this operation (e.g., Martohardjono 1993; Epstein et al. 1996). Wh-movement is a syntactic operation that results in the Wh-word (*what, which, when, where, how, why,* etc.) in some languages such as English, French, and Italian being placed in front of the sentence (e.g., What did you eat for dinner yesterday?). In comparison, this syntactic operation does not exist in languages such as Chinese, Japanese, Korean, and Bahasa Indonesia. The wh questions in those languages have their wh-words in the unmoved position, otherwise known as *remaining* in situ (e.g., 你昨天晚餐吃了什么? "You yesterday dinner eat what" in Chinese).

However, the very existence of wh-movement is important in explaining the different degree of ungrammaticality in the following two sentences:

(a) Which mayor did Mary read the book that praised?
(b) Which car did John spread the rumor that the neighbor stole?

(From Epstein et al. 1996)

Both sentences[1] are ungrammatical. However, there is an intuition in native speakers of English that the (a) sentence is worse than the (b) sentence. The explanation is that, in (a), the wh-word moved out of a structure that is more deeply embedded in the sentence, than the structure out of which the wh-word in (b) moved (despite the fact that there seem to be more intervening words in the case of (a) than in (b)). However, if a learner comes from a language background where the movement of the wh-word does not even exist, would the learner be able to distinguish between these two types of English sentences? The learner cannot rely on the type of input that he/she may have been exposed to, whether in naturalistic or instructional environments, because it is highly unlikely that such (ungrammatical) sentences ever get produced. Martohardijono (1993)'s study on Chinese and Indonesian learners of English show that, yes, these learners do demonstrate sensitivity to the difference between these two structures, just like English native speakers. Such sensitivity is then attributed to learners' ability to access Universal Grammar that ultimately explains the constraints on the movement of elements in the sentence.

Another POS learning situation was examined at the syntax-semantics interface by Dekydspotter et al. (2001). They probed the interpretive properties of continuous (3a) and discontinuous (3b) *combien* ("how many") in Second Language French. They were interested in finding out whether L1 English/L2 French learners show sensitivity to the subtle interaction between scope and syntactic position:

(a) Combien de livres est-ce que les étudiants achètent tous?
How-many of books is it that the students buy all?
How many books are all the students buying?
(b) Combien est-ce que les étudiants achètent tous de livres?
How-many is it that the students buy all of books?
How many books are all the students buying?

Both questions (continuous and discontinuous) can be answered in terms of the number of books bought by each student – let us call it the "narrow scope" reading. However, the continuous sentence (3a) can also be answered in terms of the number of books in common – let us call it the "wide scope" reading, which (3b) cannot have. For example, suppose that Mary, John, and David constitute the students in the scenario. Each of them plans to buy four books as shown in the following: Mary (Book A, Book B, Book C, Book D); John (Book A, Book E, Book F, and Book G);

[1] These two sentences ought to be judged with the understanding that they are derived from the following two kinds of sentences (as an example) where the wh-words query the underlined parts: "Mary read the book that praised the mayor of New York." and "John spread the rumor that the neighbor stole the red Mercedes-Benz."

David (Book A, Book H, Book I, Book J). The narrow-scope reading answer to the question would be 4, which is available to both the continuous and discontinuous French question sentences. The wide-scope reading answer would be 1 (i.e., Book A), which is available only to the continuous French question, but not the discontinuous one. English does not have a contrast between continuous versus discontinuous structures, as the ungrammaticality of the literal gloss for (3b) suggests. Only the continuous structure exists in English (*How many books are all the students buying?*) which, just like the continuous *combien* structure in French, allows both narrow-scope and wide-scope readings – meaning that, the answer of 4 or 1 are both correct for the English question. If all that the learner has access to is properties of his/her first language (English) and French input, then they are not in a favorable position to acquire the continuous-discontinuous contrast. First of all, the discontinuous structure is not only absent in English, it is also relatively rare in the kind of input the participants in the authors' study are exposed to (classroom). Most importantly, the learner encounters an almost insurmountable learnability problem. This is because even assuming that learners are exposed to the discontinuous structure, it is very hard for them to infer from input alone that the discontinuous structure is not simply a "rewrite variant" of the continuous counterpart. The reason is that "in every situation in which the discontinuous *combien* interrogative can be uttered and a true answer provided, the continuous *combien* interrogative can also be uttered and the same true answer provided. There is thus no situation of use that can disabuse the learner of the belief that [the discontinuous *combien*] is a rewrite variant of [the continuous *combien*] (p. 186)." Given this unfavorable condition, it was therefore remarkable that some of the participants in the study (from the Advanced proficiency group) were able to successfully distinguish between these two structures in terms of the range of semantic interpretations allowed. The authors attributed the performance to the learners' ability to access Universal Grammar, which provides the theoretical explanation (universal semantic procedures and the Empty Cateogory Principle) for the structural contrast being acquired.

Native Language Influence, Linguistic Universals, and Pedagogical Implications

This chapter has approached the discussion of language learners' intuition from two perspectives: knowledge derived from native language properties and knowledge derived from universal principles. A review of the relevant literature shows that both sources can form the basis of learners' intuition. These two perspectives may inform pedagogy in different ways. The pedagogical application for a theory that emphasizes differences between the first and the Second Languages seems clear (e.g., the Contrastive Analysis Hypothesis, Lado 1957). One would advocate comparing languages and focusing instruction on those areas where L1 and L2 differ. Such an approach still exerts some influence in Second Language phonology and pedagogy (Edwards and Zampini 2008). Indeed, work showing that first language effects on

learners' ability to perceive new phonetic contrasts can be ameliorated (Logan et al. 1991) with sufficient training is encouraging.

The insight that Universalists' work affords to classroom practice would be: which linguistic properties could benefit from classroom instruction, and which ones would emerge naturally in learners' grammar anyway (without the intervention of instruction)? It has not always been the case that theoretically oriented language acquisition research directly addresses the question of pedagogical issues. But some recent developments (e.g., Whong et al. 2013) are a welcome change. Some of the linguistic properties that have been experimentally shown to possibly benefit from instruction in Whong et al. (2013) include *null subjects, word order, ordering of multiple adjectives, semantic notion of specificity, overpassivization errors*, and *perception of articles in oral input*. Take *overpassivization* as an example. In English, only transitive verbs can be passivized: "John wrote the book" → "The book was written by John." On the other hand, intransitive verbs cannot be passivized. Nonetheless, it has been observed that Second Language learners from various first language backgrounds frequently make mistakes such as the following:

(a) My mother was died when I was just a baby.
(b) The most memorable experience of my life was happened 15 years ago.

(Zobol 1989: 204)

The verbs in these sentences (*happen, die*) are intransitive ones and should not be passivized. Yet, learners use them in passive structures as if they were transitive verbs. Curiously, learners do not overextend the passivization structure to all intransitive verbs. They generally do not, for example, produce sentences like the following:

(a) John was coughed a lot because he had an itchy throat.
(b) Mary was walked 3 miles and she got very tired.

The reason is that intransitive verbs like *die* and *happen* (known as *unaccusatives*) have the same underlying syntactic structure as regular transitive verbs (e.g., *write* and *beat*). On the other hand, intransitive verbs like *cough* and *walk* (known as *unergatives*) do not share the relevant syntactic similarity with transitive verbs, even though on the surface, all intransitive verbs share the same syntactic environment as seen in the following:

John died	*die/happen* type of intransitives (unaccusative verbs)
John coughed	*cough/walk* type of intransitives (unergative verbs)

This is known as the Unaccusative Hypothesis (Burzio 1986). As mentioned, Second Language acquisition research has indeed shown that learners treat these two types of intransitive verbs differently. A theoretically informed language teacher would then know that s/he needs to focus the energy on *die/happen* types of intransitive verbs as they are more vulnerable to erroneous overpassivization. Hirakawa (2013) asked whether focused instruction on this kind of verbs where learners (with Japanese as their first language) were explicitly taught the ungrammaticality of passive

unaccusative verbs produces any effect. It was found that the group that received the explicit instruction did perform better than the control group that did not. What such research has highlighted is that, first and foremost, a good theoretical understanding is important in informing pedagogy in terms of what should be prioritized in teaching. Linguistic properties that would naturally emerge in learners' grammar system do not necessarily have to be taught (e.g., the different degrees of ungrammaticality of wh-questions and the different interpretations for discontinuous vs. continuous *combine* structures discussed earlier). On the other hand, those properties that have been empirically demonstrated to be receptive to the beneficial effects of instruction should receive priority. As teachers and learners do not have unlimited time for instruction in all areas of grammar, prioritization is important.

Additionally, native language and linguistic universals are not necessarily mutually exclusive to each other in the account of language learners' knowledge/intuition. In looking at segment substitution patterns made by Russian, French, and Japanese speakers learning English, Weinberger (1996) found that the error patterns are explainable by recourse to a combination of a universal principle (underspecification of phonological features) and language-specific differences (which features are specified and which are not in a particular language). In syntax too, there are approaches that hinge on the interaction of linguistic universals and language-specific properties: for example, Hawkins and Chan (1997)'s Failed Functional Features Hypothesis. Specifically, in Hawkins and Chan (1997), the L1 Cantonese/L2 English participants were not able to entertain an English-like syntactic analysis (wh-movement) for sentences they were judging due to constraints from L1, but were nonetheless able to assign a syntactic analysis that is within Cantonese parameters but at the same time constrained by linguistic universals. An understanding of the ways in which native language and/or linguistic universals can contribute to forming learners' linguistic intuition is essential to any pedagogical approach that aims to make use of such intuitive knowledge.

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Chapter 9
Manifestations of Intuitions in the English Language

Anselm Premkumar Paul

Introduction

"Do we say that the conference fees are *subjected to* a GST of 7 % or the conference fees are *subject to* a GST of 7 %?" This question sparked off a lively debate among friends at work. A google search on the frequency of use for both phrases retrieved fairly comparable results. A straw poll among selected colleagues yielded more in favour of "subjected to". The debate was finally settled by a neatly crafted email, complete with citations from 'authoritative' sources justifying why "subject to" would be the correct phrase in the given instance. With that email, came closure for seemingly everyone.

Such debates on the use of the English Language are not uncommon and should on the contrary, be warmly welcome (or is it warmly welcomed?) in the language classroom. They are often settled quickest when sources of authoritative and expert knowledge are referenced. Rarely is there an examination that goes beyond. This is puzzling. In a modern world with ever-evolving knowledge and democratic access to information in large part because of the internet, judgements of correctness or wrongness should be delayed for as long as we have yet to find an answer as to what exactly is it that makes one source of information more credible than the other. Should it be a surprise if we find them both wrong?

The word 'selfie' miraculously found a spot in the much acclaimed Oxford dictionary. This might have been cheered by those who appreciated a succinct description for self-taken photographs of themselves that they painstakingly post on social media. However—and with a frown—I wonder why self-portrait would not suffice.

A.P. Paul (✉)
e-mail: anselmppaul@gmail.com

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Likewise, one can imagine a language teacher cringing at the sight of the word 'chillax' in his or her learner's composition, but having to relent when shown that this word too, is in the Oxford dictionary, and therefore legitimate. By whose power is the authority of the dictionary granted? The interesting irony is that the power granted to the Oxford dictionary is from none other than the very ones who depend on it as a source of authoritative knowledge—the everyday users of the English Language. Oxford "adds words that have been used widely over a number of years" (Oxford 2013). This itself should be sufficient reason for us to regard with healthy scepticism sources of authoritative claims.

As a young student, I vividly remember being told that human beings do not sweat, only animals do. The correct term that we were instructed to use was perspire. It was only years later when I returned to sit in a classroom full of other trainee English Language teachers when this view was surfaced and challenged by a linguistics professor, Dr. Lawrence Zhang. I have now come to understand that while perspiration is a formal word, and perhaps more favoured in scientific writing, there is nothing animalistic about the use of the word sweat other than its use in the old age maxim: "Horses sweat, men perspire and women glow".

Peering outside to validate external claims, we ought to remember to turn the same lenses inwards to examine our own intuitive responses—without regarding them as being any inferior. Why had some of us been tempted to use "subject to" and others, "subjected to"? "Maybe 'subjected to' sounds right," someone offered. But what makes something "sound right" to someone but not to another? What does *sounding right* sound like in the first place?

This spirit of questioning can and should go on and was introduced in the preceding chapter. At the end of the day, the aim is not to arrive at a winner in the form of rightness or wrongness, but to celebrate the new knowledge and rich learning birthed from such discourse. We may not want to interrogate the validity of every utterance that we encounter in the classroom. But when a dissonance is met, the dialogue that takes place will deepen learning for both teacher and student.

Consider the snippet of a Grade One pupil's corrected work as depicted in Fig. 9.1 (reproduced with permission from http://www.catch-fortywinks.com/2013/09/there-is-a-fairy-tale-module-in-primary-1/). The topic was 'Fairy Tales', and the teacher had given the class jumbled sentences to which they had to re-arrange to form coherent sentences. Why did the teacher have an issue with green fields being beautiful? How had the learner come to expect a Fairy Godmother of being capable of such evil? Speculations are rife, and they will remain speculative for the two time-sensitive voices that matter the most—the learner's and the teacher's—are absent.

In Science education, there seems to be wider acceptance of the terms 'alternative conceptions' and 'intuitive ideas' in place of the term 'misconceptions' to represent student ideas that are not in agreement with modern science—indeed Tan and Tan argued as much, in their chapter earlier in this book. It is argued that the prefix 'mis-' implies a "wrongness of a student's conception" (Read 2004, p. 2) and perhaps is inaccurate a descriptor. The latter is an enlightened stance from

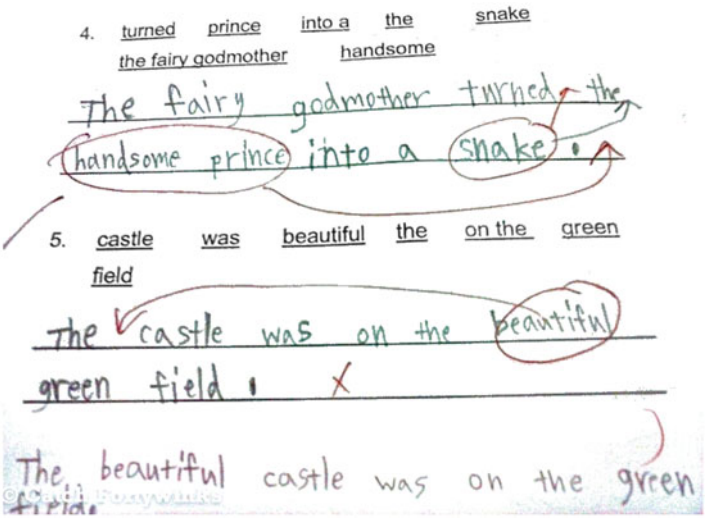

Fig. 9.1 Mono-narratives in fairy tales

which language education could benefit. Categorisation has an effect on perspectives (Lakoff 1990) and with the lack of alternatives, the teacher would be inclined to judge all views apart from the authoritative view as wrong. Such finality could bring about a premature halt to learning and should be accorded sparingly with much discernment.

In the spirit of this book, and from henceforth, the term 'intuitives' should be used to refer to manifestations of the Disciplinary Intuitions that learners bring with them to the language classroom. There are of course, deviant intuitives and expected intuitives, i.e. intuitives that are either in agreement or disagreement with the teacher's. The message that this chapter (and the next) hopes to convey is a simple one: a deviant intuitive cannot and should not be considered a mistake until it has been tabled for a dialogical inquiry. This chapter interrogates common deviant intuitives encountered in the English Language classroom, offers some speculative reasons for them and discusses the dissonances that they result in. In the subsequent chapter, I propose the dialogic pedagogy that seeks to provide a space for the teacher and the learner to interrogate intuitives.

The Unintuitiveness of the English Language

There should be no shortage of deviant intuitives in the English Language classroom. The English Language is notorious for its unintuitiveness. The following age-old poem sums this unintuitiveness best. Its author remains anonymous.

The Craziest Language

We'll begin with a box and the plural is boxes;
But the plural of ox should be oxen not oxes.
Then one fowl is a goose, *but two are called geese*.
Yet the plural of moose should never be meese.
You may find a lone mouse or a nest full of mice;
Yet the plural of house is houses, *not hice*.
If the plural of man is always called men
Why shouldn't the plural of pan be called pen?
If I spoke of my foot and show you my feet.
And I give you a boot, *would a pair be called beet*?
If one is a tooth and a whole set are teeth
Why shouldn't the plural of booth be called beeth?
Then one may be that, *and three would be those*.
Yet hat in the plural would never be hose.
And the plural of cat is cats, *not cose*.
We speak of a brother and also of brethren.
But though we say mother, *we never say methren*.
Then the masculine pronouns are he, *his and him*.
But imagine the feminine, *she*, *shis and shim*.
So English I fancy you will agree.
Is the craziest language you ever did see.

This lack of intuitiveness is not restricted to the formation of plurals. Taking a jibe at the English Language's lack of pronunciation-intuitiveness, George Bernard Shaw, the famous Irish writer, once proposed that 'fish' be spelled as 'ghoti' (f = *gh* from rou*gh*, i = *o* from w*o*men, sh = *ti* from na*ti*on) (Pinker 1994). Words that are spelled the same can have different pronunciations. Known as homographs, an example includes record (rɪˈkɔrd) as a verb versus record as a noun (rɛkərd). One is likely to say, "Please do record (rɪˈkɔrd) all your expenses" but say "John set a new world record (rɛkərd) in the race." Another variant of the homograph are words that are spelled the same but with totally different meanings. For example, 'lead', which can either refer to the chemical element (lɛd) or a person who shows the way (lid). The complication does not end here. Homonyms are words that are spelled the same, have the same pronunciation but have different meanings. For example, 'bark' can either refer to the sound a dog makes or the covering of a tree. Then, there are homophones—words with the same sound, but different spelling and meaning. For example, "son" and "sun" or "hear" and "here". To push it even further, consider antagonyms, which refer to words that mean the opposite of itself! You may clip your fringe to keep it in place or clip it to shorten it.

There are two important implications. First and foremost, given the unintuitiveness of the English Language, we have to start with the premise that our learners have done very well. The English Language is clearly a difficultly unintuitive language to master, and for them to be able to communicate in the language—in written and spoken form is itself laudable.

The second implication, largely when the deviant intuitive is produced, is that it must be met with a strong sense of empathy. The Tamil Language may have 247 letters, but with each letter mapping to a unique sound, pronunciation for instance,

is relatively straight forward. This is likewise true for the Malay Language. The Chinese Language is helped by the pinyin system which ensures consistency.

In the *Sunday Times*, Singapore (6 October 2013), an anxious parent wrote in to Parenting 101 with a concern that his or her 7-year-old daughter "spells 'medicine' without an 'e', and 'intelligent' with a missing 'I'." The resulting advice was provided by a psychologist. While accepting missing letters in spelling could be due to a developmental process which would require time for the child to 'catch-up', she warned that it could be a learning difficulty that would require examination by the relevant specialist. However, we ought to query how exactly is the development of a child related to missing letters in spelling? If we regard the developmental process as a biologically determined black-box, then there can be no further dialogue. Her recommendation, on the other hand, seemed only partly contentious. Her advice was for children to inculcate the habit of speaking out the syllables as they spell. Given the unintuitiveness of the spelling of English words, that seems unlikely to fix the problem. In this specific instance, the 'e' at the end of 'medicine' is a silent 'e'. There will be no sound to voice. That being said, it would be a useful way for the parent or teacher to identify the cause of missing letters. Is it possible that the child could be spelling the word 'intelligent' as she pronounces it? My 4-year-old daughter pronounces 'cockroach' as 'crockroach'. I am somewhat convinced that she will adhere to the spelling of the latter when a need arises for her to write 'cockroach'.

My 4-year-old boasted to me the other day, "I drawed a mermaid, Papa!" How do I communicate to her in a way that makes sense that 'drew' would be the correct word to use? Children's inflections that adults are so often amused by, should be the greatest indication that serious issues exist with our language.

Miscomprehension or Being Misunderstood?

Ralph Waldo Emerson once famously said, "To be great is to be misunderstood". This is a phrase teachers would never like to hear in their classrooms. Yet, it demands that we query if it is really all that abnormal to misunderstand. In the day-to-day questions that we pose to our learners, we may have all encountered the learner who completely misses the mark in his or her answer. In my book of marking symbols, is the symbol 'TW', which stands for 'Totally Wrong'. I reserve the use of it when I mark reading comprehension assessments for responses that do not even come close in meaning to the stated answer on the mark scheme.

The problem is more pronounced with what is commonly referred to as higher-order thinking questions. Singapore learners continue to shine at global literacy tests. Out of 45 countries that participated in the 2011 Progress in International Reading Literacy Study (PIRLS), Singapore emerged 4th (Ministry of Education 2012). Despite this laudable achievement, a closer analysis of the results reveals a shortcoming that must be addressed if we are to improve. While Singapore learners achieved on average a highly commendable 76 % Correct Response in the Retrieval and Straightforward Referencing component, they achieved a 59 % correct response

for the Interpreting, Integrating and Evaluating component (Mullis et al. 2012). It is evident that the higher-level reading proficiencies of Singapore learners lag behind their lower-level reading proficiencies. A quick scan of the results reveal that this problem is not specific to Singapore, but to most other countries.

We often attribute comprehension problems to language deficiency, and to remediate, we burden learners with more practice or simply the command to "Read more!" (This teacher has done that). Yet, if we were to count the number of times that we ourselves have been misunderstood or misunderstand others, it would quite easily surpass all the number of TWs we could ever dish out. The difference is that in real-time communication, we often have the opportunity to clarify with the party or parties involved. With only one shot at getting it correct at the examinations, our learners do not.

Yet, even in the classroom, it seems that the space for clarification opportunities may not be so open. A study done by Vaish (2008) as part of the CORE project of the National Institute of Education on 273 primary and secondary English lessons from 51 schools across Singapore found these classes "teacher-fronted and monologic" (Vaish 2008, p. 366). From qualitative coding of transcripts from English teachers' delivery of a unit of lessons, she noted that 83 % of talk in primary school classes, and 82 % of talk in secondary school classes were curriculum related and given by the teacher. The remaining duration was either filled by silence or one-word answers by learners. It was only an "extremely small percentage of time" (Vaish 2008, p. 371) that had been spent listening to student responses and for student-directed activities. What was even more disturbing was that the interaction pattern was "not discernible from primary to secondary school in Singapore showing a static pedagogy throughout school" (Vaish 2008, p. 371).

Our pedagogical approaches do not allow the space for the interrogation of the rightness or wrongness of a learner's disciplinary intuitive as they are manifested in the responses. Responses which fall within the range of acceptable answers are rewarded while answers that do not are usually passed over without much thought. It is not easy for a teacher to mull over the response of all his or her learners.

Before proceeding any further, perhaps we should question what it means to comprehend. Current understandings of text comprehension are based on cognitive science (Verhoeven and Perfetti 2008). When faced with a text, the reader begins with the decoding of individual words. Some authors prefer to use the term recoding (e.g. Sadoski et al. 2000). The visually presented word is recoded from the textual representation to the audible version by silent articulation. As each new word or phrase is recoded according to its linguistic units, the reader connects it to a continuously updated representation of the text. However, recoding by itself is not sufficient. For text comprehension to occur, the reader has to bring his or her 'prior knowledge' to the text. There is a lack of clarity on the exact nature of this prior knowledge. Consistent with Paivio's dual coding theory, this is a mental image of the text based on the reader's prior knowledge. For example, if the word 'knife' appears in the text, the reader is likely to connect this to an image of a knife.

It is important to also note that this model, arising from the cognitive science domain, is based on the information processing model. The information processing

model has been criticised for reductively regarding the mind as a computer. It is nonetheless a model that has helped educators understand how to design instructional material. A further value of this model is that it highlights the importance of a reader's prior knowledge in facilitating comprehension. It is not just language ability that will help a learner to comprehend a text, but his or her knowledge of the themes of the text, objects referenced places mentioned, etc. that are critical in determining a reader's comprehension of the text.

In classrooms, there is a tendency to down-play the importance of a reader's prior knowledge in comprehension firstly because it is beyond the control the teacher and secondly, it is assumed that this can be easily compensated. The advice that is typically offered to teachers who have learners that may not have sufficient knowledge on the topic is to 'fill' them with visual input for example, movies or videos related to the reading selection. It is assumed that this would be sufficient compensation to facilitate text comprehension and to make it easier for them to follow the sequence of ideas in an unfamiliar text.

Some years ago, I encountered a learner who exited the examination hall with a jaded expression. "I don't understand the passage," he had moaned. When I tried to query him what it was about the passage that he had not understood, his response was simply, "Everything." It then dawned on me that it was not language, but his lack of experience with the topic that had let him down. As I scrutinised the passage, I realised that it was set in Ancient Egypt and foreshadowed by information on Pharaohs, Pyramids and Egyptian gods. Even though the questions posed clearly tested comprehension of language and not a candidate's knowledge of these topics, one cannot help but wonder the extent of the advantage a student who had been more familiar with Ancient Egypt—perhaps as a result of conversations at home, or even a privileged study trip to Egypt—would have had.

As a further example, consider what the phrase: 'Green man flashing' would mean to person who has never attempted to cross a street in Singapore. This person may have a dictionary understanding of the words 'green', 'man' and 'flashing', but it is not possible for him or her to come close to comprehending the phrase without the necessary background knowledge.

Even when learners have problems with the vocabulary of the passage, the time-pressed advice is to "check the dictionary". Even the meaning of a word is heavily loaded by an individual's culture and experience. 'Village', even if defined at length as 'a group of houses and associated buildings, larger than a hamlet and smaller than a town, situated in a rural area' will conjure different images say for a person from Scotland and Singapore.

A related issue with schooled comprehension is that it moves learners towards uniform responses. For every comprehension question, mark schemes reveal a specified answer or at best, the range of acceptable answers. This is the only way to ensure fairness in assessment across learners being assessed by different examiners.

We seem too quick to ascribe the term 'misconceptions' rather than a viable 'alternative conception' to learners who may have an interpretation of the text that deviates from a tolerable norm. Once encountered, we engage our gears and work

towards carrying out appropriate intervention activities to help learners resolve their misunderstandings.

This approach seems to be an irony considering reality reveals that getting learners to arrive at a similar answer is counter-intuitive.

On the night of 8th of December 2013 in Little India, a worker from India was fatally run over by a bus. This led to an unfortunate riot involving an estimated 400 foreign workers that resulted in massive damage to public vehicles and property, and injuries. This incident was a shock to Singaporeans, and many turned to new media to express their shock. I found it interesting to note that the comments—admittedly not necessary positive—were richly diverse in perspectives. In fact, the value of an online comment is precisely in its ability to draw a fresh or previously unexpressed insight. Run-of-the-mill comments are likely to be passed over without much attention. Straits Times writer Linda Heng writes about the online comments relating to the widely circulated footage of a police car being overturned by a mob. There was one comment that referred to the police as "a disgrace", perhaps for being an easy pushover. Another comment extolled the police and congratulated them for showing restraint by not drawing arms or firing tear gas. I remember coming across another comment that hailed the police together with the paramedics as heroes for putting their lives at risk for public service. "Same video. Different observations. Vastly different conclusions." I fully agree with this observation by Linda Heng. Citing the Ladder of Inference, she highlights the natural bent of people to "draw vastly different conclusions from different, limited or even the same set of data". That which we have thus far reduced to 'prior knowledge', she articulates as "beliefs, assumptions and experiences".

Alfred Korzybski's Structural Differential model (Korzybski 1948) attempts to offer an explanation on the uniqueness of personal experiences. It is deserving of some attention as we aim to better understand how our learners make meaning of their everyday experiences with events, people and objects, and more importantly, connect that to text that they read. Consider Fig. 9.2.

Korzybski's main argument is that the difference between a person and an animal is the former's capacity to abstract beyond the Objective level. The Structural Differential model illustrates how this abstraction takes place.

Interestingly, Korzybski refers to everything around us as not a thing, but an event. Indeed, chemistry teaches us that the smallest unit of matter is an atom, which consists of protons and a neutron, and electrons that are in constant motion or in a "mad dance" (Korzybski 1948, p. 387), "which is different every instant, which never repeats itself". Because the Event occurs at the submicroscopic level, we are not able to perceive it. What exactly is this event, there is no objective certainty for this Event has an infinite number of characteristics.

However, we are able to perceive an abstraction of it. Our perception is through our neurophysiology—our sense of taste, sight, smell, hearing and touch. We may perceive our abstraction of the Event to be something 'green', 'shiny' and 'roundish', but we cannot see the "wild dance of electrons" that it really is. This abstraction is an Object. Korzybski's point is that the moment we abstract, we attend to what our neurophysiology leads us, and not everything that is objectively occurring. We lose

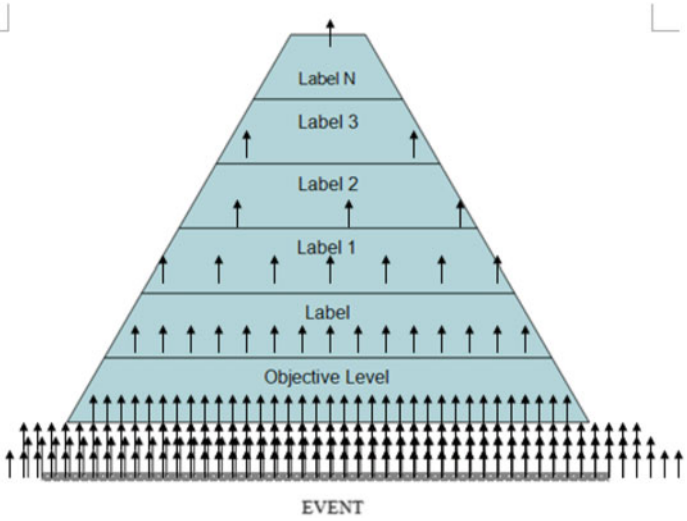

Fig. 9.2 Abstracting from the event level to the label

a tremendous amount of information in the process of abstraction from the Event level to the Object level.

A creative video by the Transport for London on Road Safety for cyclists (http://www.youtube.com/watch?v=Ahg6qcgoay4) highlights the difference between the Objective Level and the Event Level. In the video, we are first warned that the presentation is "An Awareness Test". We see two teams—one decked in white, and the other decked in black. We are then invited to count the number of passes the white team makes. Players from both the white team and the black team then move rapidly around, passing a basketball to teammates. Focussed on our aim of counting the passes of the white team, we keep our eyes on the ball thrown from player to player and count each pass that we see the white team complete. At the end, we are informed that the number of passes made were 13, which is likely to be the same number we had arrived at. However, just as we begin to feel the sense of achievement, the narrator asks if we had seen the moonwalking bear. Most viewers, like myself, would have missed the oddly out of place bear mascot, making its way to the middle of the court and comically performing a moonwalk. The message of the video is then displayed, "It's easy to miss something you're not looking out for." Even though our eyes were glued to the screen, we had missed out on an object that would have caught our attention had we not been so engrossed in counting the number of passes. Seeing but never perceiving.

The number of characteristics that an Object has is large but unlike the Event, it is not infinite.

At the next level of abstraction, we place a label (Label L) on our abstraction of the Event. With our Object that is 'green', 'shiny' and 'roundish', we say that it is a Green Apple. We point to a Green Apple, and ask a young child, "Would you like

this green apple?" The moment we ascribe a label to our abstraction of this Event, more characteristics are discarded. For example, we may stop attending to the scratch on the surface of this Green Apple.

However, as intelligent human beings, our abstractions do not stop here. We may go on to form a limitless number of abstractions, with each abstraction, more characteristics are discarded. If we simply refer to the Green Apple as an Apple (Label 1), we have lost the colour of it amongst the other characteristics that a Green Apple may have such as its sourness. More often than not, when a person mentions Apple, the image that is conjured is an apple that is red. If we further abstract, and tell a friend that we had a fruit (Label 2), then even more information is lost. This friend, if he or she so cares would be left to guess whether this fruit refers to an Apple or a Banana, for example. We could stretch it even further and refer to this fruit as merely 'food' (Label 3).

The implication of the Structural Differential for comprehension of information whether it is from a History Textbook or a Literature Text is that rarely is it written to be close to the lower levels of abstraction. That would require far too many words. It would not be economical to describe everything in a way that is as factual as possible. When the word, apple was mentioned to our friend as the fruit we had after lunch, she would have automatically conjured an image of it based on her experiences. An apple, being something that is somewhat concrete, may not cause too many difficulties in understanding. We may simply point at an apple and say, "This is an apple". But what if, in a text, a key topic less concrete is featured such as 'friendship'? Can we assume that we all view a friend the same way? Even at work, where we sometimes spend half our lives, we struggle to decide if a co-worker is a colleague or a friend. Even if we were to refer to a dictionary, we note that a friend is defined as 'a person attached to another by feelings of affection or personal regard'. We could go on to question what does it mean to regard someone? Or, what does it mean to be 'attached' to someone? We could go in circles in the dictionary, and still have to fall back on our ever-evolving personal feelings, attitudes, experiences, beliefs, assumptions, biases and culture.

Creativity is a valued trait. Well-meaning educators keen to inculcate this in their learners often resort to the oft-heard metaphorical phrase "Think outside the box!" But a foreseeable challenge I should think learners would face in trying to understand this phrase is that they would need to know what the box looks like if they are to think outside of it. I suppose the more important question to ask is, whose box are we asking learners to think outside of—theirs or ours?

The second important implication is that there is a gap between the verbal and non-verbal. Korzybski says this best when he writes, "Whatever one might say something 'is', it is not." The label that we give to a person, place or event is not the person, place or thing. There are universally agreed terms to help facilitate communication. However, particularly as educators, and as we teach learners from backgrounds different from ours, we need to be constantly aware that different people view the world differently, and perhaps refer to things differently. When we have wronged someone, and we wish to acknowledge that, we say "I'm sorry". In the Tamil Language, the equivalent is *Enna Mannichudunga*. The literal

translation is "Please forgive me", which has a different connotation in the English Language.

The Structural Differential model highlights how we form representations based on our personal feelings, attitudes, experiences, beliefs, assumptions, biases and culture. It also highlights that this representation is not equal to 'what is'. Yet in formal schooling, there is a tendency to equate what a person knows to what he or she is able to articulate. A person cannot be said to know unless he or she is able to represent what he or she knows. Likewise, we cannot say that a person has comprehended unless he or she is able to represent this comprehension. This could be further complicated if we were to consider recent advances in neuroscience.

Studies in neuroscience have concluded that a very large percentage of brain activity (95–99 %) is beyond consciousness. While, this figure is contentious, there is widespread agreement that a very large percentage of our brain activity is beyond our consciousness (Lakoff and Johnson 1999). The implication is that most of our representations are based on personal feelings, attitudes, experiences, beliefs, assumptions, biases and culture that are not conscious.

I remember a somewhat heated discussion among friends on the meaning of the word 'pedagogy'. All were able to quote the arguably two most important elements—teaching and learning. Yet, their articulation was telling of their beliefs. There were those who alluded to teaching being the act of imparting information, and learning therefore to be the act of receiving this information. And there were others who felt that teaching would entail a teacher co-learning (often unlearning) with learners and learning being a process where learners simply improve on previously held notions whatever they may be. Their representation of their understanding of the word 'pedagogy' reflected beliefs either about a Transmissionist-way or a Constructivist-way of teaching. They may not be conscious of their pedagogical beliefs, which could have been attributed to myriad of factors including personal experience, assumptions, etc. Yet, all would probably contest to the labels of Transmissionist Teacher and Constructivist Teacher if ascribed to them, rightfully so. "Whatever one might say something 'is', it is not". Even as I would like to declare that I am a Constructivist, I recall several occasions when I had adopted Transmissionist methods.

More interestingly, the anthropologist William Reddy pointed out that the very act of expressing an interpretation of something, for example one's interpretation of pedagogy, shapes his or her interpretation of it. Once again, this is out of the conscious realm. Related to this is an interesting phenomenon that has been empirically validated and widely documented: the verbal overshadowing effect (e.g. Dodson et al. 1997). Studies have shown that describing an object that has been previously seen by a person will impair his or her future recognition of it. An important implication of this is in the recognition of suspects in a lineup by eyewitnesses. If the investigation officer were to ask an eyewitness to describe a potential suspect's face before the identification of the suspect from the lineup, this description could possibly cause the eyewitness to identify the wrong suspect even though this eyewitness's initial memory of the suspect might be correct.

A further example on the evidence of unconscious processing of information is findings from the widely used implicit association tests. These tests that were first

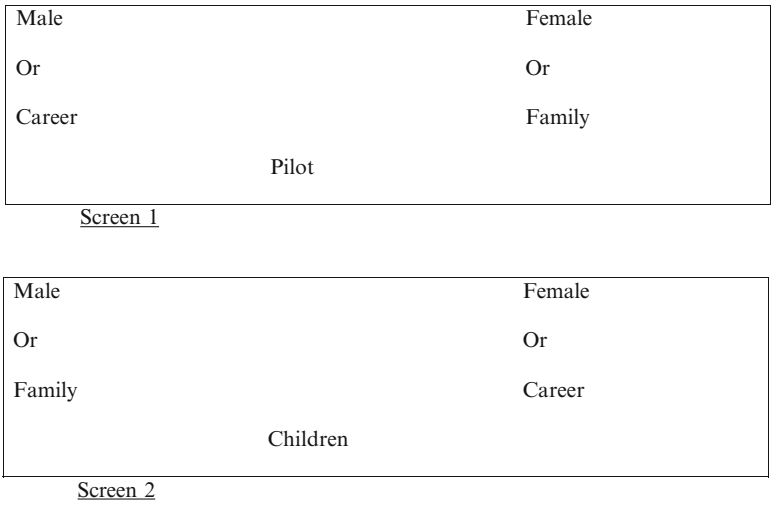

Fig. 9.3 An example of an implicit association test

introduced by Greenwald et al. (1998) measure the strength of automatic association between concepts in a person's memory. The test typically involves a subject having to make a selection between two concepts when a word is flashed. As an example of how this could work, consider subjects who are faced with the screen similar to the one depicted in Fig. 9.3. They would be instructed to press the left arrow key on their keyboard if they feel that 'pilot' belongs to the category on the left or right arrow key if they feel that it belongs to the category on the right. The response times are recorded, and subjects are exposed to other Career-related concepts (e.g. 'professional', 'salary' and 'business') interlaced with family-related concepts (e.g. 'parents', 'marriage' and 'relatives'). To ensure that the subject is not making a weighted decision, male names and female names are thrown in. The next iteration involves swapping the concepts and the test is repeated (Screen 2). The above example has been adapted from Harvard University's Project Implicit website publicly accessible at http://implicit.harvard.edu/. The website reports that this test "often reveals a relative link between family and females and between career and males". People tend to associate careers with being male, that they would for being female. This is manifested by faster response times for Career + Male combinations than Career + Female combinations. This test has unveiled gender attitudes that may not be conscious. How often have we come across in conversation a person talking about a 'lady driver' or a 'male nurse'? Is the specific reference to gender necessary?

The act of comprehension is an incredibly complex process. When our learners read a text, they bring to the text not just their prior knowledge of the topic, but their attitudes, beliefs, biases and assumptions—in essence their entire Selves. Their unique Selves influence their comprehension of the text in unique ways that are not necessarily conscious. Along the same lines, it must not be forgotten that behind a text is an author who has likewise written the text with his or her entire Self.

Standard Spoken English: Whose Standards?

The Speak Good English Movement (SGEM) was launched in 2000 to promote and maintain the use of Standard Spoken English (SSE) amongst Singaporeans (Rubdy 2001). The SGEM refers to Standard English as "grammatically correct English that is universally understood" (SGEM 2000). Elsewhere, SSE is referred to as English that is 'internationally accepted'.

English Language teachers, as role models of the language, have been tasked to ensure that the standard of SSE does not deteriorate (Farrell and Tan 2008). Unfortunately, this task of nurturing SSE in schools has not been an easy one. It is plagued with ambiguity and challenges. Central to all of these ambiguities and challenges is competition from the Singapore variety of English, commonly known as Singlish.

Singlish has been defined as a colloquial form of the English spoken by Singaporeans. It is characterised by a mixture of local expressions, code mixing, discourse particles, reduplication and direct translation (Chng 2003). Table 9.1 below highlights some of these features.

Despite the large majority of Singaporeans speaking and understanding Singlish, it is believed that such a variety of English will not be internationally accepted and universally understood. The approach has therefore been to replace Singlish with SSE (Cavallaro and Chin 2009). Has this been easy?

Singlish holds an iconic status in Singapore. As the "common language of the Singapore people" (Chng 2003), it is a language so revered by Singaporeans that it has spilled over into television programmes, plays and even social media. It is the "glue that binds Singaporeans together" (Cavallaro and Chin 2009). Moreover, it is the language, which Singaporeans typically use with family, friends and others in informal interactions. However, as Gupta (1994) suggested, Singlish is also

Table 9.1 Key features of Singlish

Feature	Example	Meaning
Local expressions	Whenever I call his name, he acts blur	Whenever I call his name, he pretends not to hear me or he ignores me
Code mixing	Your handwriting is lagi worse than mine!	My handwriting is bad. But yours is even worse than mine
Discourse particles	Stop making fun of me lah!	*Lah* is usually used at the end of a phrase for emphasis
		I really want you to stop making fun of me
Reduplication	He might be small in size. But he is a martial arts expert. Do not play play	Do not take it too lightly
Direct translation	A: Will you be going out later?	Direct translation from Mandarin, which means "We'll see about it"
	B: See how	

considered a 'Low' variety of the English Language, whereas she describes SSE as the 'High' variety. It is used in formal situations such as in education business and political communications. Hence, it seems that when people use SSE in communication, they sound more 'educated'. Yet, in sounding so, they plant a distance between themselves and the hearer. In contrast, when speakers use Singlish, they close this distance, but at the expense of sounding 'uneducated'.

Therefore, in advocating the use of SSE in place of Singlish in schools for all forms of communication, learners will be caught between a rock and a hard place once they are out of school. The dilemma faced by our learners is best described by Milroy and Milroy (1999) as cited in Tan and Tan (2008). They say that in communicating in SSE with peers and family, learners choose status over solidarity since communicating in a High variety of English such as SSE is associated with prestige. However to the extent, one values the moral, social and emotional support of his or her friends and family, one will choose to adopt their familiar speech patterns, i.e. Singlish. Thus, SGEM and other platforms advocating SSE will be met with either strong resistance at the expense of less than confident language skills in the face of a non-Singlish speaker or mindless compliance at the expense of distancing themselves from their hearer.

For the shift to SSE to take place, learners will need to go against the grain of society. In nurturing SSE, we will be forcing learners to choose status over solidarity. It is not only going to be very difficult, but it might also not be very fair to them.

In schools, the message is clear: only SSE should be spoken. Thus, even when interaction skills are taught and learners are required to introduce themselves to their friends, this is to be done in SSE. The approach is to "keep the non-standard out completely, and ignore its existence" in hope that learners will be so "immersed in SSE that it will somehow be absorbed into their learning systems" (Tan and Tan 2008).

The role of the teacher in any educational reform is pivotal (Bartiromo and Etkina 2009). As rational human beings, teachers will act on something with the right convictions only if it is consistent with their beliefs. Therefore, teachers' beliefs about Singlish and SSE will influence the instructional methods they adopt to nurture SSE in their learners (Eisenhart et al. 1988).

A descriptive case study was undertaken by Farrell and Tan (2008) to examine the beliefs of three Singaporean English Language teachers regarding language policies and Singlish. The studies revealed that all three teachers were confused about the government's approach to Singlish and the SGEM. The teachers agreed that Singlish is acceptable in informal situations and that it should not be abolished. They even confessed to using Singlish to build rapport with their learners. It was also noted by the researcher that the teachers used instances of Singlish even in formal instruction. However, the teachers did admit that it was their duty to correct learners' oral use of Singlish—but only because learners would be "taking Cambridge papers in the future" and that their speaking had an effect on their written English. It was also apparent that Standard English had been falsely associated with British English.

In essence, it was clearly evident that the beliefs of teachers were not in harmony with the drive towards SSE. Teachers did not seem informed on the economic value of SSE in international communication. Neither did they seem willing to comply with the underlying message that SSE should pervade all forms of communication in English Language. Their approach to nurturing SSE could at best be summarised as being half-hearted, and even so for the wrong reasons, i.e. academic success of their learners.

As a language educator, I am able to associate with this struggle. Noting that she had had waffles for every other day for breakfast, I passed a comment to my daughter as she munched on, "Everyday eat waffle". This is a direct translation from Mandarin. Even though my dominant language is not Mandarin, this would have been picked up from my social *milieu*. I am fully aware that saying this same expression to an Australian for example, is likely to be met with raised eyebrows. Yet, even in retrospect, I find this more economical. I see a young child at the playground attempting dangerous, and I contemplate uttering the caution, "Be careful", but choose to go with "Be careful ah.." dragging the last syllable in the hope that I sound friendly enough not to scare the young child.

Yet, in the official spaces of the classroom, it is only SSE that I advocate. I worry that ungrammatical elements of Singlish would creep into their written work or that my learners encouraged by their teacher's own Singlish will slip into complacency and altogether abandon SSE.

Almost equal in importance to teachers' beliefs are learner attitudes towards a language. Their perception of Singlish and SSE will strongly determine how they respond to instructional methods to foster SSE, and the challenges that English Language teachers will need to be aware of.

A survey via a questionnaire was administered to 260 learners from five "non-elite" schools by Tan and Tan (2008) to gather their views on Singlish and SSE. It was found that a large majority of the learners used Singlish most of the time in their communication. 89.2 % spoke in Singlish with their friends and classmates, and 83.5 % of them communicated in Singlish with family and relatives. Learners used the lowest level of Singlish during lessons with their English Language teachers (22.3 %) even though this figure did rise to 37.7 % outside of lesson-time. Interestingly, 47.7 % of learners communicated with their Mathematics teachers in Singlish during Mathematics lesson, significantly more than the Singlish they would use with their English Language teachers. Likewise, even though learners felt that it was strongly inappropriate for English Language teachers to use Singlish, it was only "mildly inappropriate" if it had been used by their Mathematics teachers. This difference might once again indicate that learners viewed the studying of SSE only for academic gain.

Thus, the preference for learners to communicate in Singlish and their view of SSE is certainly a challenge of mammoth proportions. Yet, to say that learners were apathetic and hostile towards SSE would be false. They did see value in SSE albeit not for the right reasons.

With Singlish banned in the official spaces of the classroom, current teaching strategies are largely reactionary and didactic. A common strategy is to rephrase learners' sentences (Farrell and Tan, 2008). Consider the example below.

Teacher: Where is Jane?
Student: Sick. Go home.
Teacher: Oh, she went home because she's sick. (*Rephrase*)

I have heard of teachers who at times punish the use of Singlish in a somewhat friendly manner. This is implemented via small fines, typically 5 cents that contribute towards the class fund, and the writing of lines.

In summary, the current approach rests on the foundations of behaviourist learning. This attempts to condition learners' desired responses by controlling extrinsic factors. It ignores learner's real-life experiences, existing knowledge and cognitive processing abilities. It is thus argued that such an approach and its corresponding instructional methods are clearly ineffective in nurturing SSE. Learners may rule out certain phrases in their communication with the English Language teacher. However, since they may not understand how and why this may not be appropriate all the time, it may lead to them using it at a formal presentation or with an international visitor. Even if learners intend to communicate in SSE given a situation, the mental cues they receive from the situation may not match what they have learnt in class, causing them to respond with inappropriate language (Nagowah and Nagowah 2009).

While it is true that Singlish is globally incomprehensible and considered inappropriate for formal communications, it should not be considered something to be feared. It does serve its function in promoting solidarity and building friendly relationships within the right context. There should be room in the curriculum that enables learners to explore Singlish. This acknowledgement and hence exploration of Singlish in the official curriculum is supported by Gutierrez's Third Spaces Pedagogy (Gutierrez et al. 1999). Gutierrez argues that much of traditional classroom practices take place within the confines of the "sanctioned and legitimate" curriculum referred to as official spaces. Since the official spaces are based on a generic curriculum, it cannot be sensitive to the rich diversity of backgrounds inherent in the classroom. When learners attempt to engage in counterscript, for example, sidetalk in Singlish with one another, they are said to be operating in unofficial spaces. This counterscript is usually suppressed or ignored. The traditional teacher always functions in official spaces. However, when the teacher designs activities that draw from the personal lives, experience and background of learners, he or she is creating what is referred to as Third Spaces. Gutierrez proposes that the use of Third Spaces expand learning. It makes learning relevant and thus engaging to learners. It also offers more opportunities for learners to raise misconceptions and for teachers to address them. It is also more important that empathy is nurtured in learners so that they seek to understand the person they are communicating with. It cannot be wrong to throw in a colloquial word if it is followed through with an explanation. On the contrary, it could be enlightening.

The Challenge of 'Teaching' Creative Writing

Creativity, Critical Thinking, Communication, ICT literacy, Collaboration and Life Skills are hallmarks of the twenty-first century learner (Anderson 2008). As such, the role of creative writing in the English Language (EL) Syllabus holds plenty of promise. One can imagine a classroom of aspiring authors selflessly exchanging rich story ideas, critically examining various story elements, actively generating original plots and resourcefully adopting a range of literary devices in an effort to communicate their masterpieces to interested readers via the Internet. This seems all encompassing of twenty-first century learning.

Yet, the current reality is far from this vision.

Creative Writing includes texts such as poetry, personal recounts and narratives. Since poetry is largely covered as part of the separate subject, Literature, the two main types of Creative Writing that is taught as part of the English Language curriculum are Personal Recounts and Narratives. The distinction between the two is almost negligible. With narratives, learners narrate stories from the perspective of someone else, i.e. the text is written in the third person. In contrast, personal recounts require learners to narrate stories from a first-person perspective, i.e. the text is written in the first person.

In comparison to Academic Writing and Functional Writing, the teaching of Creative Writing is complex. Academic texts have a fixed structure, typically adhering to the universally accepted five-paragraph essay format with each paragraph guided by a crisp topic sentence. Writing in simple English and expressing oneself succinctly are important for academic writing. In contrast, Creative writing requires learners to draw extensively from their own experience and imagination. Learners would then need to craft the appropriate language to match their ideas. This is writing that is closely linked to their personal lives. In the ideal world, they would be free to write in any way that expresses how they truly feel. However, since the ultimate goal is the national examinations, learners (and teachers) often find themselves ignoring how accomplished authors write, relegating their personal convictions and adopting the strategies that are spoon-fed to them by their teachers in the hope that this would help them get their distinction.

To further complicate the teaching of creative writing, examiners point out several what may be deemed 'difficult to fix' problems. Apart from the complaints of grammatical errors (in particular with tenses and subject–verb agreement), and microscopic handwriting, a common remonstration is that writers do not write from their personal experience. Closely related to this are laments of "run-of-the-mill stories" and "predictable" and/or "familiar storylines" presumably memorised stories rehashed to suit the topic. While it may then be inferred that examiners are looking for imagination in the responses, at the other end of the spectrum, it is remarked that too much imagination could lead to your writing being "far-fetched". Vivid descriptive phrases and rich vocabulary are important qualities of creative writing. However, examiners have responded to the teaching of these by introducing vocabulary like "purple prose" and superfluous writing in their reports. These terms are used to refer

to chunks of prose, allegedly memorised or pre-prepared that do not quite flow and/or fit in with the rest of the story.

The teaching of creative texts is typically based on the Genre-based approach and delivered via Derewianka's Curriculum Cycle. For practice, the Flower and Hayes Process Writing Model is used.

The Genre-based approach is derived from Halliday's functional theory of language (Grabe and Kaplan 1996). Halliday viewed language as arising out of a need for people to communicate for functional purposes. Martins (cited in Grabe and Kaplan 1996) (extends this by producing a definition of genre as "a staged goal oriented social process"; Richardson 1994). Thus, the goal of the narrative writing genre is to entertain readers only as agreed upon by social and cultural norms. In written texts, genres have a form and a structure that aids communication. Likewise, in this case, creative writing texts have two main forms—narrative writing and personal recounts. Narrative writing texts also have specific features, for example, they are written in the past tense. Narratives also adhere to a structure consisting of an orientation, complication and climax that is followed by a sequence of events and finally, a resolution.

The Genre-based team of advocators preach that the forms, structure and features of creative writing as a genre must be "taught, understood and critiqued" (Grabe and Kaplan 1996). In addition, they argue that there are genres that are more valued than others and these must be made explicit so that all learners have equal access to the means for learning (Richardson 1994).

In short, the current way of teaching makes the features of creative writing to learners explicit by the teacher. There is no room for negotiation and learners have to accept these features as a package deal. However, there is rarely a pure text type. Consider the lyrics of most famous songs, and you would understand this tension. Most songs are personal recounts or life experiences or a singer's poetic expression of his or her emotions.

The features of a Creative Writing text are taught to the learners topically via Derewianka's Curriculum Cycle. Derewianka's curriculum cycle has three main phases: Modelling, Joint Construction and Independent Construction. The essence of this model is to grant learners autonomy over tasks gradually as they grow in competence.

Modelling. Typically, in this phase, the teacher distributes models to the class. He then points out the specific feature of interest to them via these models. For example, should the teacher wish to teach the use of dialogues, he may distribute excerpts from the novel *Kite Runner* by Khaled Hosseini and point out to the class how the author has used words in place of the all too common "said", such as "yelled", "pleaded", etc. to convey the manner in which something is said.

Joint Construction. In this phase, learners together with the teacher make sense of that which has been taught. For example, learners may be expected to complete a cloze passage by filling in the blanks with appropriate speech verbs. The teacher may then go through the answers, reinforcing the use of speech verbs.

Independent Construction. At this stage, the teacher presumes that learners are confident and competent enough to do a task on their own. Learners may be asked to complete a story, say Roald Dahl's *Man From The South* using dialogues.

On completion of the teaching of all the stipulated features of narratives and personal recounts, the Flower and Hayes process writing model will be adopted for learners to receive more practice and to reinforce the taught components.

The process writing model advocates the following phases: pre-writing, drafting, editing and revising (Flower and Hayes 1981).

Pre-Writing. This usually takes the form of the teacher leading a brainstorming session for ideas on the topic. The class contributes ideas by shouting out their responses.

Drafting. Once sufficient ideas have been explored via the pre-writing phase, learners start to write a draft of the compositions independently.

Editing. Here, learners exchange scripts with their peers, typically the one seated next to them. The teacher then guides the class through a process of editing. The teacher might, for instance, present on the whiteboard a properly punctuated dialogue and instruct the class to check if the dialogues in their peer's compositions are correctly punctuated. Mistakes are circled in pencil.

Revising. Learners receive their edited scripts from their peers. They then rewrite their compositions factoring the feedback received. The final drafts are then submitted to the teacher for marking and further feedback.

This approach is not archaic and is on the contrary based on theories validated by research. However, what is immediately glaring is that it does not seem to take into full account the age of technology, which according to Collins and Halverson (2010) calls for a revolution in educational practices.

In this approach, the teacher is regarded as the expert and is clearly in control. This is ironical considering most teachers are not accomplished creative writers themselves. In fact it is rare to encounter English Language teachers who write apart for the purposes of setting examination papers. Yet, they dictate what aspects of Creative Writing should be taught and how it should be taught.

A common argument the author has had with advanced learners is that all narratives should be written in the past tense. Learners are often quick to point out published stories written in the present tense. However, the rationale for teaching learners to write in the past tense is that many non-native speakers have problems with their tenses. This is mainly because the use of tense is absent from their Mother Tongue languages (this theme was elaborated upon in the preceding chapter). These learners are likely to be confused if they have to write a composition that switches from the past to the present and vice versa. Out of simplicity and convenience, the teacher insists that they use only the past tense. However, with such prescriptive methods, it is clear that learners would not fully grasp the idea of the use of tenses in creative writing. This also further reinforces learners' dependence on the teacher hence greatly stifling creativity and critical thinking.

All learners are taught the same topics and they are expected to grasp these topics at the same pace. For example, the genre-based approach advocates that narratives should begin with an 'orientation' despite the fact that many successful writers do not being their narratives with an orientation. Therefore, all learners are taught to begin their narratives with an orientation. Teachers too, at times distribute a list of descriptive phrases for learners to memorise and use in their compositions. Learners think that this will impress the examiner and help them to score a higher mark.

Perhaps, this gives rise to the "purple prose", "superfluous writing" and "run-of-the-mill stories" pointed out by examiners.

There is little customisation to cater to learners' interests and difficulties.

The Flower and Hayes Process Writing Model is well respected and widely used. However, there are two criticisms regarding this approach.

Firstly, it oversimplifies the writing process. As Odell (1988) points out that writing depends on circumstances, emotions, affect and "being able to alternate between seeing the big picture and in becoming immersed in the very small points". A linear approach to writing does not factor these complexities. He concludes by stating that to him, the writing process is "complex, messy and elusive."

Secondly, the Flower and Hayes model has completely ignored the role computers can play as partners in cognitive activities (Kim and Reeves 2007), i.e. as tools that learners can think with. Rapid revision of texts is possible thanks to word processing tools. For example, with a single tool such as Microsoft Word, writers can create an outline, recursively work on it until it becomes the final product. Our learners have been labelled "Digital Natives" (Prensky 2001) in view of the hours they spend immersed in digital artefacts such as their handphones, computers and more recently tablet PCs. In terms of writing, learners are already actively authoring blogs, posting Facebook notes and exchanging instant messages and e-mail. Yet, it is ironic that an approach that keeps ICT out of the class should be adopted.

Writing, to me, is a complicated and messy process. A plan usually involves a brief outline of some sort, which may in the end have only a faint resemblance to the final piece. I may decide to start anywhere and revise my writing multiple times before discarding the draft altogether to start afresh. A lot of my writing is done as I drive, in the middle of a run or shower. I sleep on my writings, wake up and usually have fresh ideas. I may decide to do a mind map only at the end of my writing to check for coherence of ideas. As I write, I have a family of readers in mind. Focussing on getting my point across, I communicate to them and anticipate their perspectives. I help them to see 'where I am coming from' by sharing my experiences. In essence, I am in a dialogue with them, and I take full advantage of the revisions that the asynchronous nature of ICT affords. I choose to adopt clarity and simplicity to make my writings accessible to a wide range of audience. Yet, in schools, writing is more often than not a prescriptive approach we spelled out earlier. It is constrained by time, i.e. learners do often have a fixed time to complete their writing. While I write to communicate, it seems that our writers seek to impress.

Concluding Remarks

This chapter has presented brief snippets of learners' intuitives manifested in the English Language classroom. It has made the argument that we may not necessarily be aware of these intuitives—be they deviant or expected or inconsequential—because as educators, there is rarely an examination that seeks to establish a response to a "where are you coming from?" question. As you read this chapter, you may

have agreed with some points, while disagreeing with others. It is this precisely this sort of discourse, if articulated for further interrogation, that will create further opportunities for the improvement of individual ideas, and collective advancement of the knowledge of a community of learners. The question I address in the subsequent chapter is: to what extent do our current methods of teaching allow the space for such a discourse?

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Chapter 10
Disciplinary Intuitions in the English Language Classroom: Implications for Practice

Anselm Premkumar Paul

In the preceding chapter, I discussed the notion of Disciplinary Intuitions in the context of the English Language. I chose to focus on deviant intuitives—manifestations of intuitions in the English language that are not expected. I argued that it is important to interrogate not only the deviant intuitives but also the expected intuitives. This interrogation would enrich learning. However, I also argued that our current pedagogical practices may not be conducive for such an approach.

In this chapter, I put forth the proposal of a dialogical pedagogy as an approach to interrogate the Disciplinary Intuitions a learner brings to the language classroom.

Introduction

I should begin by sharing my views of language and language learning. This would help readers understand where I am coming from. I will then go on to present some theoretical foundations of approaches that I subscribe to before putting forth a proposal that I hope would show how these principles can be enacted in a reading lesson.

The American philosopher John Dewey (1859–1952) hailed language as "the tool of all tools the mother of all significance". There are four key reasons why I strongly concur with him.

First, language makes us human [Social Psychologist George Mead (1863–1931)]. Facilitated by language, our biological potential of becoming a distinct human being

A.P. Paul (✉)
e-mail: anselmppaul@gmail.com

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is the outcome of our interactions with others. Through language, we see ourselves through the eyes of others, and this eventually leads to the formation of our Selves.

Second, language allows us to learn about our *milieu*. It is through language that we come to learn what things signify to others, and note that they do not necessarily signify the same for us.

Third, language is a tool that is socially constructed. Dewey refers to it as "fundamentally and primarily a social instrument", and "a device for communication and a tool through which an individual comes to share the ideas and feelings of others". Austro-British philosopher Ludwig Wittgenstein (1889–1951) said that if one's use of language is not deemed sensible to others, it is nonsense, and I suppose, no matter how sensible it sounds to oneself. Mikhail Bakhtin (1895–1975) argued that words hold no objective meaning. Last, but not least, language helps us to think. Cultural psychologist, Lev Vygotsky (1896–1934) credited the cultivation of the inner speech of an individual to the use of language that this individual has been exposed to in the social plane. Many others have likewise written extensively about the relationship between interaction, language and thought.

The usefulness of a tool is only revealed through its use. In line with the many great thinkers mentioned, we should therefore expect to see the focus on how this 'tool of all tools' can be used to facilitate communication, foster interaction, shape thinking and essentially guide actions. Most importantly, we would expect to see lessons that highlight the single most important feature of language and that it is socially constructed.

However, in what might loosely be construed as classrooms in which 'traditional' instructional approaches are adopted, the tool often becomes the focus instead of what can be achieved through it. In many classrooms, the English Language is presented as a means to doing well in the examinations, and hence a path to a successful career. Many English teachers would wave job advertisements specifying the necessity for good communication skills in an effort to motivate learners to learn the language. Dewey would refer to such an approach as "mere preparation" for "a remote future". Such methods of teaching are not part of the lived experience of the learner, and therefore not "truly educative". There is an imbalance in focus of skills to nurture language competency. There is too much emphasis on reading and writing to the neglect of speaking and listening. Is this not a grave irony since learners speak and listen more than they read and write? The lack of competence across the range of speech genres is quite clearly evident. If you were to eavesdrop on a young (or not so young) person ordering food at a fast food restaurant, you would find that he or she is not likely to communicate too much beyond the pointing of fingers, i.e. more of an interaction with the menu than with the person receiving the order. This is not wrong, but certainly inadequate. An "I-thou" in place of an "I-it" communication pattern would pave the way for a more person-centred, gracious society. School is too far serious a place. Walk past many classrooms in many East Asian cities and you would find little difference between examination venues and classrooms. Pressured to remain silent unless permission has been granted for them to speak, learners sit as passive spectators in single rows waiting to receive information from a source of 'expert authority' on the language. One should never expect to even

faintly recognise the usefulness of a hammer by simply staring at it. Opportunity must be given for the hammer to be used in context for a specific purpose. We often wonder why our learners complain of boredom in class when so much of the material distributed to learners is useful but arguably irrelevant to the lived experiences of the learners. Articles on the benefits of space exploration, the importance of animal conservation and the boons of the Internet reflect the map and are a far cry from the territory. These readings are often accompanied by questions. Close-ended or open-ended, the right answer is usually the teacher's answer. The teaching of values through language, if at all, is either incidental or becomes the focus of the entire lesson to fulfil quotas.

The Monological Approach

Vaish's (2008) references to the predominantly monological teaching and learning culture of a Singapore English Language classroom is reminiscent of the Banking Concept of Education put forth by the late Brazilian educator and philosopher, Paulo Freire. In one of his most influential works, Pedagogy of the Oppressed (1970), Freire likens education to an act of depositing. The teacher is viewed as one bestowed with the gift of knowledge and in considering the ignorance of his learners absolute, presents himself to them "as their necessary opposite" (Freire 1970, p. 72). Learners are regarded as empty containers to be 'filled' by deposits of information which the teacher considers true knowledge. The more the containers permit themselves to be filled, the better they are as learners. Failing to acknowledge learners as historical beings who are *with* the world and not merely *in* the world, the teacher narrates to them a reality that is "motionless, static, compartmentalized, and predictable" (Freire 1970, p. 71). Freire warns that this approach to education leads to men and women who merely adjust to the world. They cannot be expected to transform the world. This approach inhibits their creative power and stunts the growth of their critical consciousness.

One can see the Banking Concept at work in a typical reading lesson. A teacher begins a lesson by telling learners the prescribed outcomes of the lesson. He then narrates to learners how they should go about attaining these outcomes. He then executes one or more tasks so that learners are able to attain these outcomes with the invaluable assistance of the teacher. Finally, learners are expected to produce the outcomes on their own without the teacher's intervention.

In a later paper, Freire, along with his co-author, criticises contemporary strategies that appear to hear the voices of learners but are essentially monologic and hence alluding to the Banking Concept of Education (Shor and Freire 1987). The Socratic questioning teaching method, where teachers asks a series of questions with the objective of helping learners to understand, is famously used in reading classes. However, the content to be understood is usually based on material that has already been covered or is known to the teacher. The teacher essentially attempts to steer the student to a correct path, i.e. the teacher's or the text's answer. Likewise, in

discussion groups, student voices can be dulled by the teacher's imposing own, and this inhibits critical challenges to the syllabus (Shor and Freire 1987).

Even though neither referenced the other, the writings of Freire are uncannily similar to the work of Bakhtin (1981, 1986). In *Problems of Dostoevsky's Poetics*, Bakhtin (1973) defined monologism at its extreme as that which "denies the existence outside itself of another consciousness with equal rights and equal responsibilities… another person remains as wholly and merely an object of consciousness and not another consciousness". Having survived the Bolshevik Revolution, the Stalinist purges and World War II, Bakhtin would have been well acquainted with life under an oppressive monologic regime.

Theoretical Foundations of a Dialogical Approach

Bakhtin's Dialogical Approach to Life

The binary opposite of the monological approach is a dialogical approach. A literature search reveals many variations of dialogue. It is the Bakhtinian version of dialogue that primarily inspires this proposal. However, we are reminded by Bakhtin himself not to neglect the other voices of dialogism. No one version of dialogism can lay claim to being a true version. Rather, it is in the dialogue about dialogism that aids us to a better understanding of dialogism.

Bakhtin's rationale for dialogism is that we live in a multi-vocal, multi-perspectival plural world, and that these voices and perspectives if different from ours are not to be merely tolerated. Instead, they are to be regarded as a precious piece of the puzzle of Truth that we are all trying to unravel. Because we are embedded in the chronotope of space and the time as the fourth dimension, a person always brings with him or her a multiplicity of possible meanings, voices and identities. To further permutate these multiplicities is the non-neutrality of everyday language. With regard to reading, a text may be a static representation of another's voice, but comprehension occurs as each person creates meaning by bringing to the text his or her understanding.

Many researchers appear to focus on teacher-talk (e.g. Jones 2010; Mercer et al. 2009). However, it is important to note that while talk does play an important role, dialogue according to Bakhtin is more than that. It is a stance one takes, inherent in both the written and spoken word, in inner and outer consciousness.

A dialogical stance requires us as educators to firstly acknowledge that there is so much more that we do not know than what we do know. The unknowns of the universe are a lot more than we can imagine, and because it is in a constant flux, the cliché that change is the only constant could not be any truer. Ancient philosopher Heraclitus once famously said that one could never step into the same river twice. We need to revisit the truths that we have come to unquestioningly embrace. For example, what does it mean to learn? If we were to search our hearts, would we

perhaps, find that we have reduced it to merely the act of recollecting? The rapid expansion of the internet, and the variety of "truths" on any one topic should give us enough impetus re-examine our beliefs. There should be no excuse for mindlessness and blind following of the tried and tested paths.

Second, we are called to be genuinely open to others who are different from who we are, and of relating to those who may have ideas and opinions that are separate from ours. If we acknowledge that we live in an ever-changing world, then we need to accept that others may think likewise. This is where the excitement should lay. When individuals share differing views on a given topic, it edifies all who are participants and even witnesses to the discussion.

Third, we should be active listeners. We should never think that what we say is 'absorbed' immediately by our learners like a sponge. Like the reader, they are active, engaged and always bring with them their own unique voices and interpretations. In the manifestations of their Disciplinary Intuitions, it is important to always keep the "Where are they coming from?" question in view.

Fourth, in discussing everyday truths, we are to be aware that truth is born of the dialogical intercourse between people in the collective search for truth. The truth is in the dialogue.

Last, even when we think we have discovered truths, Bakhtin says that one should remain open and unfinished. We must be ready to shift our positions. In the chronotope of space and time, anything is possible. We once believed that there were nine planets. Today, we learn that there are eight. Lastly, we should learn to challenge our understandings of what is appropriate and what is inappropriate, be ready to refute our beliefs, and challenge taken-for-granted truths.

Bakhtin warns against extreme relativism where we each believe in our own version of the truth and at the same time maintain a respect for the views that contradict ours. 'To each his own' cannot be a philosophy of dialogue. Every perspective must be heard if we are to make valid judgements. With extreme relativism, common in our post-modern era, argumentation is excluded and dialogue then becomes unnecessary.

Despite its inspirational, emancipatory value, I concede that the Bakhtinian dialogism is a stance that may be problematic for the beginning practitioner and those not well versed with Bakhtin. It may even be too radical. Therefore, we need to turn to see how we can blend more practice-centric elements from other dialogical approaches to support the dialogical stance.

Freire's Problem-Posing Approach

While the contrast to monologism to Bakhtin was in a dialogical approach to life, Freire's contrast to monologism was the problem-posing approach to education. Freire writes that the knowledge of the object to be known is not the private possession of the teacher, but as the object of reflection by himself and the learners. It is true that a teacher may at the start of the lesson know more about the object and

where the class is to head with knowing this object. But he or she nevertheless puts this object on the table for mutual inquiry (Shor and Freire 1987). The teacher presents the object to the learners for their consideration and then re-considers his or her initial considerations as the learners express their own. This object can be a problem in learners' lives (Wong and Grant 2009), subject material (Freire 1970) or both.

Alexander's Dialogic Teaching Principles

Alexander's (2010) five principles of dialogic teaching is also another useful guide for practitioners. The principles are elaborated upon in Table 10.1 below.

The practitioner may use these principles to check each lesson activity for adherence to these principles of dialogism. Alexander's five principles appear to be widely adopted in many studies. However, it is important to note that what is done is not as important as the spirit that guides it. The teacher's actions must stem from a dialogic stance.

Enhancing Triadic Dialogue

The triadic dialogue or three-move exchange of Teacher Initiation, Student Response and Teacher Evaluation is often considered a monological approach (IRE) (Boyd and Markarian 2011). For instance, consider the following exchange:

Teacher: What is two plus three? (Initiate)
Student: Six! (Response)
Teacher: Wrong! (Evaluation)
John? (Initiate) [New Move]

This enhances the teacher's position as an authoritarian. The teacher has no interest to find out why and how the student arrived at an erroneous answer. Recently

Table 10.1 Five dialogic teaching principles

Principle	Explanation
Collective	Teachers and learners address objects of inquiry together
Reciprocal	Learners and teacher listen to one another, share ideas and consider alternative viewpoints
Supportive	Learners express their ideas freely, without fear of embarrassment over 'wrong' answers, and they help each other
Cumulative	Learners and teacher build on answers and other contributions and chain them into coherent lines of thinking and understanding
Purposeful	Classroom talk, though open and dialogic, is also planned and structured with specific learning goals in view

researchers have re-examined the IRE exchange in the light of dialogic teaching (e.g. Nassaji and Wells 2000; Vaish 2008).

In some papers, the IRE (Initiate-Respond-Evaluate) is recast into the IRF sequence with the F denoting Follow-up instead of Evaluate (Skidmore 2006). In the line of this inquiry, this proposal considers how the triadic dialogue can be further adapted and extended with the inclusion of Information Communication Technology (ICT).

Proposing a Dialogical Approach to Teaching Critical Reading and Viewing

With copious amounts of information prevalent in today's world largely attributed to the internet, schools must expedite the nurturing of critical readers and viewers. From the casual scanning of the ingredients on the label of a shampoo bottle to the careful analysis of arguments on an on-line discussion forum, pupils must be encouraged to read and view all texts critically. The critical reading of written texts such as newspaper articles and the critical viewing of visual texts such as video clips require pupils to read between and beyond the lines. Critical reading and viewing are high-level reading processes (Li 2010).

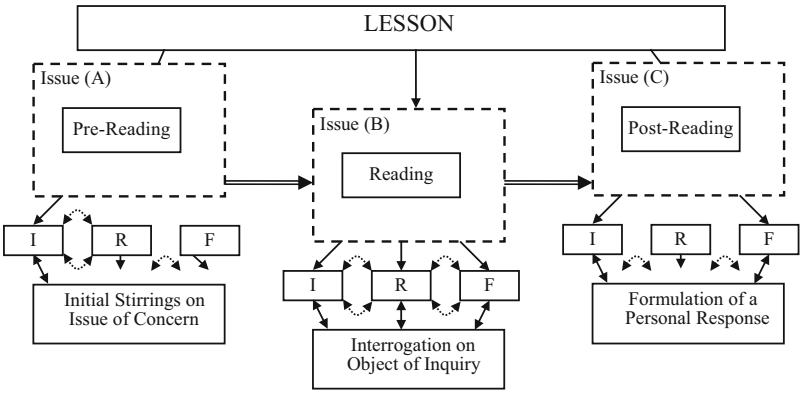
The proposed approach is guided by the following key principles:

- Maintaining a dialogical stance with Bakhtin's Dialogical Approach to Life. I posit that this is crucial to a dialogical approach. A teacher adopting a dialogical stance is guided by an ethos that will offer him or her freedom in terms of teaching methods to adopt. For example, closed questioning is often deemed to be monological. However, a teacher with a dialogical stance may use a closed question and allow it to be followed through with "extended discussion, elaborated talk and joint construction of knowledge among class participants" (Boyd and Markarian 2011).
- Teaching dialogically using Freire's Problem-posing approach and Alexander's Five Dialogical principles.
- Using an adapted version of Triadic dialogue to ensure dialogic student-to-student and teacher-to-student interactions.
- Leveraging on ICT as a tool to encourage and 'remember' student voices.

In the spirit of Freire's Problem-posing education approach to dialogue, I begin with the premise that learners are "beings in the process of becoming" (Freire 1970). Even though they may not be conscious of it, learners are already reading critically for their own purposes, but are capable of becoming more critical readers and viewers.

Please refer to Fig. 10.1 for the structure of a typical lesson on Critical Reading and Viewing.

An issue of concern is always the focus of each lesson. This should be an issue that is related to the lives of learners, and one that learners are intimately connected with.



Legend	Explanation
Lesson	The module on Critical Reading / Viewing has 8 Lessons
Issue ([Letter])	All tasks should be given in the context of an issue or problem. The letter is used to indicate the labelling on the Google-Sites.
I	The Initiate move by learner or teacher.
R	The Response move by learner or teacher.
Follow-up	The Follow-up move by learner or teacher.
Object of Inquiry	A video or article or any other stimulus.
	Free-flowing exchange of moves within a single move.
	One task leads to the next in the stated order.

Fig. 10.1 Typical structure of a dialogical critical reading lesson

Possible issues include gender discrimination, racism and national examinations. The teacher needs to have a good sense of the lives of pupils. What are the issues that matter to them? The teacher also needs to be fully aware of his or her own biases on the issue.

In tabling the issue of concern, the teacher should consider the various forces at play with the issue. Bakhtin writes about the notion of a centripetal force and a centrifugal force. The former strives to pull everything to a unified centre and is hence monological. For example, when as netizens, we join in the majority of voices and launch a tit-for-tat tirade against a person who posts racially offensive messages on twitter, we can be said to be following centripetal forces. Centrifugal forces strive to push things apart. When one chooses to stand up to verbal attacks directed at the poster of the racially offensive message and urges the rest to forgive and move on, this person can be said to be rejecting the centripetal forces. Bakhtin encourages us to reject centripetal forces. Hence, each lesson strives to unveil the centripetal

forces and encourage learners to consider the centrifugal. Educating learners to be aware of the mainstream sentiments, the status quo, and to religiously search for alternative and more peaceful solutions should be the goal of every critical reading lesson (Wong and Grant 2009). The following are some key issues that could be tabled for inquiry:

- Is there a difference between reading *normally* and reading *critically*? Why is it important to view / read something critically?
- To what extent should we allow guide dogs into public premises?
- Is Singlish bad English?
- Should national examinations be abolished?

Each lesson is divided into three main phases. To ensure that sufficient time and opportunities are given for learner voices to be heard, and to guide the teacher new to dialogical teaching, each phase is further divided into three mini-phases according to the triadic dialogue exchanges. The Initiate mini-phase typically involves a teacher posing an open question. This is followed by a Response mini-phase where learners can either verbally respond or post their responses on the Google Sites platform. At the Follow-up mini-phase, a teacher or student may choose to take up on specific responses and probe it for deeper understanding or for inviting further dialogue.

The pre-reading phase aims to establish learners' interest, background, experience and where they stand with regard to the issue tabled for dialogue. The objective of this phase is to stir learners into critical consciousness with regard to the issue being tabled. With national examinations, an Initiate mini-phase could entail learners being asked to share their experience preparing for one. What is the process that mattered or the outcome of the preparation? Regarding Singlish, learners could be asked how often they used Singlish, and with whom do they communicate in Singlish. Would they have difficulty if they had to revert to Standard Spoken English for all forms of communication? At the Respond mini-phase, the teacher invites learners to read the responses and share their reactions. At the Follow-up mini-phase, it is important for the teacher to take stock of the discussion. Where does the class stand in general? Is there a diversity of views, or are learners "holding back"? If there is a need to, the teacher should in this phase, challenge learners to consider alternative view points, ethics and so on. The teacher should stay focus on the bigger issue and not be tempted to dwell on isolated points that would not help to advance the class's understanding of the topic. It helps to have a draft the Post-Reading task prepared.

At the reading phase, the object of inquiry is a video and/or text for learners and the teacher to dialogue. This could involve the reading of one or more letters published in a forum, Facebook postings or even video advertisements. This could be followed by an invitation to learners to respond to the texts, make comparisons, draw similarities, with the teacher following-up on responses with further questions to enrich learners reading/viewing experience.

The post-reading phase requires learners to consolidate the lesson with a response to the texts/videos and the issues discussed. Consider the following tasks:

- What do you think we can do so that a shopping outlet or even a restaurant is able to appease customers who may not be entirely comfortable with dogs, and yet not have to turn away a guide dog?
- Singlish is very specific to Singapore. Given that the world is becoming a global place, and there is a need for us to be understood by the international community, what would you propose? If you had to produce a video educating a foreign visitor to Singapore on Singlish, what would go in it?

Using Kirkpatrick's four levels of evaluation (Praslova 2010), we station assessment checkpoints at each mini-phase so that in the midst of trying to solicit dialogic interactions the teacher does not lose sight of the horizon, i.e. broad learning goals. Level 1 specifies the reactions teachers should expect from learners and Level 2 specifies how teachers will know if their learners are learning. Perhaps, more importantly, the teacher needs to evaluate his or her actions against the principles of dialogic teaching. For example, with the following questions: by asking the following questions:

- Am I encouraging a cumulative response?
- Am I being supportive in helping my learners to *become* more critical readers?
- Are my learners indeed becoming more critical?

The IRF model can be extended to leverage the use of the Google Sites platform to facilitate dialogue. Classrooms are usually considered too large for dialogical interactions. It would be near impossible for the voices of every student to be heard. Yet, large classroom sizes should not be viewed as an impediment to the facilitation of a dialogical approach. Diversity of student background and experiences if brought into the lesson contribute to a rich learning environment. A platform such as Google Sites serves as a store for these voices, augmenting the limited working memories of learners and teachers. Instead of struggling to recall what a participant says, a teacher or student is able to conveniently refer to it on the Google Sites. These can be archived and referred to anytime anywhere.

Learners are also not pressured to give immediate answers. With additional wait-time, they are able to think through their responses and plan how to formulate them. Less confident and shyer learners, typically left out of discussions, will also be able to contribute to dialogues.

However, even with the additional platforms for learners to share their perspectives, a student must not be made to feel that he or she cannot remain silent. Rather, the culture that must be created is one that values the perspectives of learners even if they are starkly different from the teacher's. Along the same lines, it should not evolve into "free space" (Shor and Freire 1987). The teacher has the responsibility of facilitating the dialogue so that it heads towards the "horizon that he or she wants to get to" (Shor and Freire 1987). In this case, the horizon is that learners should become more critical readers and viewers at the end of the lesson or series of lessons.

A Word of Caution

Learners will stand to benefit from a dialogical approach. However, because teachers are deeply entrenched in monological practices, it would be a challenge for the shift to take place. Research has found that even with training, it does not take much for a teacher to assert his or her dominance or for feedback to focus on the evaluation of learner responses (Lyle 2008). Just as learners are being nurtured to become more critical readers, the teacher is likewise being nurtured to become more dialogical.

Dialogism can also be "emotionally taxing on learners" (Aukerman et al. 2008). Learners may be too used to a neat, transmissionist style of delivery. A dialogical approach may be too messy and uncertain for them. The teacher has to gain the learners' trust, be confident of where he is taking them and encourage them to keep faith with him. Additionally, the teacher has to check against an "anything goes" atmosphere (Aukerman et al. 2008). Learners should be held accountable for their assertions. The Assessment for Learning checkpoints must be adhered to, and the horizon has to be kept in sight.

Concluding Remarks

Advancing a conclusion to the present chapter would in a somewhat dogmatic sense be *un-dialogic*. After all, a dialogic stance requires one to delay finality, to adopt a posture of incompleteness and openness. I am ready to shift my position—perhaps even radically—in the light of new evidence and experiences. I am sure that my thoughts on Disciplinary Intuitions, and dialogism as a pedagogy to surface and interrogate these intuitions will continue to evolve. I shall therefore end with a personal story to highlight the value of both intuition and dialogism.

As an educator, I had believed strongly in feedback. "If we don't tell students specifically what mistakes they make, show them how they can eliminate these mistakes, and continue to check that they are not making the same mistakes, then we cannot expect them to improve," I would constantly remind my colleagues. "A teacher's job is to teach. Can we say that we have taught if they have not shown that they have learnt?" I worked religiously towards not only identifying, but memorising the strengths and weaknesses of each and every one of my students.

Just before they entered the examination hall, I would rattle the areas they needed to focus on like the manager of a soccer team barking final instructions to a player before he took to the field. "Don't forget K.I.S.S!" when I wanted them to keep their sentences short and simple for clarity. "Watch your tenses! Put your finger on every verb, and check its tense!" to those who persistently slipped up with their tenses. "Remember not to paraphrase!" to the few who insisted on rephrasing words and phrases at the risk of altering the meaning their comprehension responses. "Don't

forget to impress with your dialogues!" to those who seemed to have a knack for writing good dialogues. Sometimes, these instructions would go beyond language. "Keep your watch on the table!" Those were the students who just could not complete their paper on time. To the 'handwriting-challenged' like myself: "Write bigger, and use a point five mm pen." It was specific, custom-made feedback. I still believe in specificity in feedback. However, the one thing I wish I had done more of was to listen. Yes, I cared about them, and listened to their dreams, ambitions, struggles, stories about their friendships and families. But this listening was mainly within the spaces of the 'unofficial' curriculum. Within the official curriculum, the lecturer-coach and at times motivational speaker took over. Interrogating their intuitives may or may not have achieved the desired examination results, but more importantly, it would have showed them dialogism.

We are probably familiar with the purposes of think-aloud protocols, which is a strategy educators use to make thinking visible. Think-aloud protocols help students to watch how teachers or the 'significant other' (to borrow the ideas of the famous Soviet educational psychologist, Lev Vygotsky) approach a text or solve a problem. It is hoped that the ways this 'significant other' approach the task will be 'internalised' into inner speech or inner dialogue for the students should they themselves encounter a text or a problem on their own. Along the same lines, interrogating students' intuitives in a warm conversational tone with questions such as, "What was that word in Malay you said? Could someone explain it to me, please?", "I'm interested to know where you got the idea that cats and dogs don't like each other?" or "Why do you think it's wrong to begin a sentence with 'Because'?", and sincerely listening to their responses or following up on them with further questions, would have modelled dialogism. Not only would this in some way teach them to be likewise dialogic with others, but this may perhaps also lead them to learn to be dialogic with themselves.

The epistemological practices of our education systems do not seem to give due regard to intuitions as a way of knowing. Students are taught to *know* mainly from authority, to a certain extent and depending on the subject, their senses and in a most limited way from their personal experiences. Depending on one's intuitions and worse still expressing them are risky ventures in a system that values homogeneity, conformity and where responses are constantly evaluated against authoritative 'answers'. Yet, as I think about questionable decisions resulting in failed marriages, scam-falling, hiring mistakes and an angry mob that could have been quelled had a police commander activated the Special Operations Force sooner, I wonder to what extent should we blame an unexercised or stifled intuition? In a world of an overwhelming amount of information, it might be an opportune time to consider the place of intuition in the curriculum and with that, a dialogic pedagogy as a means to nurture it. If dialogic practices are prevalent enough in a child's social *milieu*, I believe this same child will mature into a dialogic adult. Dialogism breeds dialogism. I strongly believe that society has much to benefit from a spirit of dialogism. Indeed, this theme will be taken up in the next chapter.

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Chapter 11
Surfacing Intuitions Through Visual Novels

Richard Lee and Gabriel Chia

Introduction

Many teenagers between the ages of 16 and 18 have to make important decisions which would eventually chart where they will head towards in the future. Speaking as adolescents within this age demographic ourselves, we know that many of our peers may not necessarily be aware of how much impact their decisions potentially have on their lives.

Games for learning are one type of technology that has been developed in an attempt to "help them (students) deal more effectively with situations outside the original context of learning" (Shaffer 2008).

In this study, a subset of such games is explored. Visual novels are interactive fiction games in which the gameplay mechanic typically consists of intermittent decision points. They potentially offer a relatively low-cost and accessible way to explore games for learning; this is because while more traditional games may seek to immerse the player in a rich environment through gameplay, the genre of the visual novel tends to emphasise content and narrative itself and leaves relatively little room for player autonomy. Both mediums allow a player to experience the situation from a character's point of view, and thus allow curriculum designers to potentially design for epistemological appropriation.

Notwithstanding the preceding paragraph, visual novels are a relatively less explored and developed genre with respect to games for learning. For our internship project, we decided to conceptualise and author a visual novel which would allow players to make important life-impacting decisions which could influence the protagonist Dan's future.

Singapore has had three masterplans for Information and Communications Technologies (ICT) in education so far, and such masterplans have laid the

R. Lee (✉) • G. Chia
e-mail: threadofethariadne@gmail.com; denied05@gmail.com

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foundation for teachers to integrate ICT into their daily lessons. On the topic of utilising ICT to aid teaching, Lim (2006) suggested that "to learn scientific concepts more effectively, students need to engage with the content and not merely learn by rote. This is especially true when the scientific concepts are more abstract."

This study, therefore, sought to emplace a visual novel in a larger learning design with a post-play dialogic discussion, whereby cognitive dissonance was deliberately introduced to the learners. Such dissonance created opportunities for intuitions about the potential impact of such decisions to surface during the dialogic discussion and would be consistent with Lim's (2009) idea of "learning by expressing".

A visual novel was created from scratch to examine its viability as a medium for learning. The visual novel had a branching storyline and the narrative was mostly composed of dialogue relating to how a student in Singapore might choose to pursue his / her post-Secondary education either by enrolling in a Junior College or a Polytechnic. Figure 11.1 shows how the branching storyline was depicted visually.

As this study was intended to serve as a proof of concept within the context of an internship, the content covered by the visual novel was limited to the post-secondary education in the current Singapore education system; this choice was made as this topic could be related to easily by the intended participants.

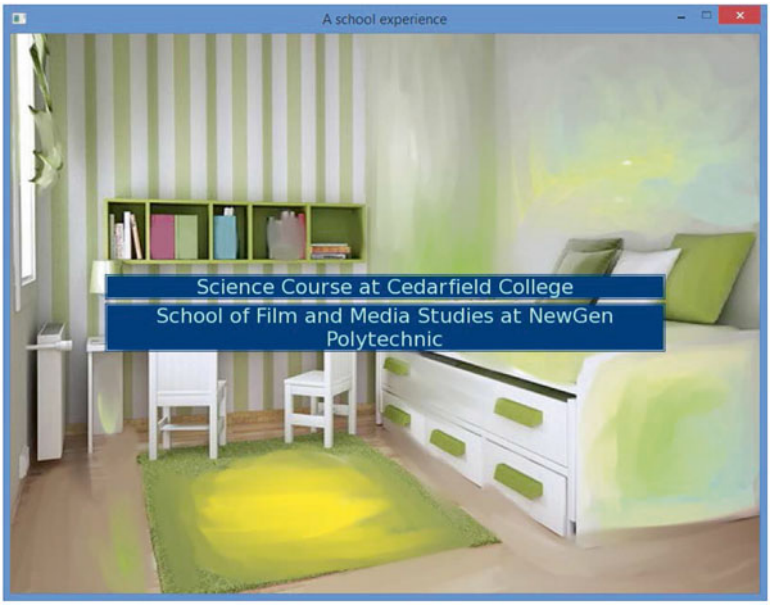

Fig. 11.1 Screenshot from the visual novel

On Games and Learning

Research has already been done in the fields of digitally mediated learning environments, and it has been shown that games can be used to yield positive effects for the gamer, both academically and socially (e.g. Squire 2011). This study can be seen as drawing inspiration from that of Squire's.

However, while Wang (2008) suggests that the affordances of ICT are too good to pass up, little research has been done on the viability of visual novels as a learning medium, and this study can be considered as novel in that regard.

Lim (2009) has described the "Six Learnings framework" on which this study was based. Originally developed as a curriculum design framework for the design of learning environments in immersive environments and fictive worlds, this study represents our attempt to translate the framework to the domain of the visual novel. Briefly, the Six Learnings are:

- Learning by exploring
- Learning by collaborating
- Learning by being
- Learning by building
- Learning by championing
- Learning by expressing

Of these six learnings, the present study described in this chapter leveraged "Learning by being" and "Learning by expressing". The visual novel was constructed to enable the player to appropriate a diversity of possible perspectives from which to view the unfolding narrative(s) and deconstruct them during the post-play dialogic discussion.

By 'Learning by being' is meant the learning that results from explorations of self and of identity. This type of learning is congruent with Brown and Duguid's (2000) understandings of 'learning to be.' Such learnings involve the assumption of identities and dispositions through enculturation. Role-play is a common learning design in the immersive world of Second Life, as witnessed by the use of holodecks in English as a Second Language (ESL) learning at the *English Village* region, for example. Another example would be the performance of the works of Shakespeare by several groups within Second Life, to varying degrees of authenticity. The relative ease with which avatars can be customised and changed facilitates 'Learning by being' to the extent that this be a specific learning goal of the design intervention.

'Learning by expressing' could be argued to be distinct from the preceding five Learnings, in the sense that while the five are to do very directly with the learnings that results from activity in-world, 'Learning by expressing' focuses more on the representation of in-world activity to the 'outside world' (i.e. to an audience who are not necessarily in-world). This kind of learning is congruent with Hung's and Chen's (2008) notions of the dialectical interaction which they term 'self to reification.' Thus, for example, 'Learning by expressing' would encompass the authoring and editing of blogs, podcasts and machinima about in-world activities and tasks.

The learning that results would encompass storyboarding, the technical aspects of audio- and video-editing, as well as the principles of literary critique and creative writing. 'Learning by expressing' is an obvious 'learning' to be adopted by a school's media department and/or languages department.

On the topic of principles of learning that are built into good computer games, Gee (2007) has also suggested a few principles that games should exercise, and that "good learning requires that learners feel like active agents not just passive recipients", among other things. Such principles further reinforce the idea that in any form of learning, students should be able to feel that they are participating in the learning instead of plainly being fed information without any additional input from the teacher. In particular, Gee has described three distinct identities that emerge in the context of gameplay. The player always brings to the game his or her real-world identity. This is the person as he or she is known in the real world. The game also offers a virtual identity, represented by the character—in this case, Dan—one plays in the game. Such a character can be implied; it does not necessarily have to be explicitly rendered on the screen. Third, and most intriguing from the perspective of research into life-choices, is the projective identity. This represents the projection of the player, with his or her goals and intentions, onto the game character. The result is a so-called blended character constituted by the player's intentions but constrained by the repertoire of actions associated with the game character. This conflation between the player and his or her virtual persona as they jointly enact a trajectory of experience within the game space of the visual novel creates not only a sense of 'being there' (embeddedness), but also—importantly, in the context of life-choices—a sense of being (embodiment).

This leads to the definitions of the 'e-textbook' and 'e-workbook' analogies that will be used in this study. As conceptualised by Lim, in an 'e-textbook', ICT is being utilised to present information didactically as canonical truth, from the outset of the learning activity. On the other hand, the idea of an 'e-workbook' describes a pedagogical approach in which the learner takes on a more active role in learning; thus, unlike a passive learning process whereby information is fed to them, players of the visual novel learn through the decisions they make. The pedagogical process-orientation of an 'e-workbook' is to leverage the affordances of environments—such as virtual worlds and visual novels—as canvases upon which learners may express their pre- and misconceptions, their naïve beliefs, and evolving understandings with regard to topic in question. Such collaborative participation-as-play makes for more enduring conceptualisations around the topic through the learners' authentic embodied experiences-as-protagonist. As a result of this, students are potentially able to appropriate the epistemic frames of the respective discipline, and thereby to develop disciplinary intuitions. The contrast between the e-textbook and e-workbook paradigms is represented in Fig. 11.2 below.

It therefore follows that engagement is key to enable the student to learn effectively and this served as the motivation for the development of the visual novel. During the conceptualisation of the visual novel, we were mindful that we wanted the novel *not* to be a standalone learning intervention in and of itself. In other words, we did not want the learning takeaways to be derived solely from the gameplay per se, which would

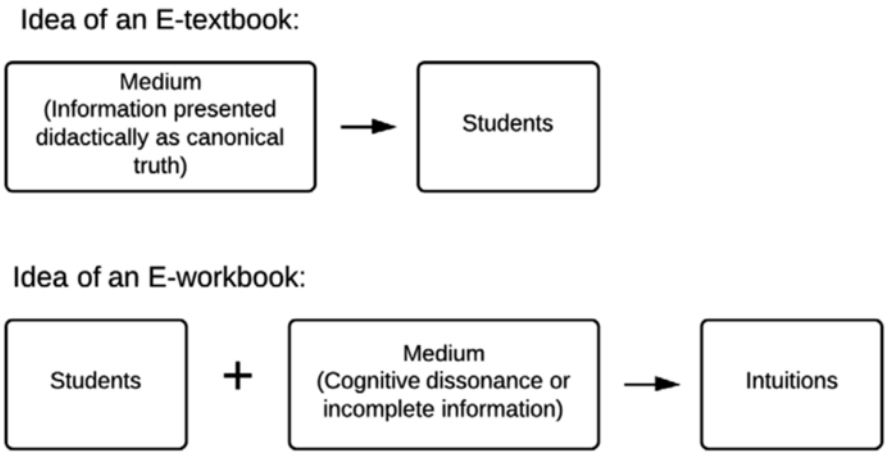

Fig. 11.2 Two differing pedagogical paradigms

have been akin to an e-textbook metaphor. This was in no small measure because we felt that as adolescents, we already had access to no dearth of (well-meaning) resources designed to 'dispense' advice about life-choices in rather didactic ways.

The Visual Novel and Post-play Dialogic Discussion as e-Workbook

We therefore chose instead to investigate how the use of a visual novel might be helpful in surfacing otherwise tacit intuitions about the potential impact of decision making among four 16- to 18-year-old Singaporean students who had already been widely exposed to ICT and life-choice resources in both formal schooling and informal after-school contexts.

The visual novel was crafted in such a way that the narrative structure was left deliberately brief, thereby presenting players with only a limited number of narratival branches to follow (see Fig. 11.3). Significantly, one corollaric advantage of the design choice along an e-workbook metaphor was that it considerably reduced the costs (particularly in terms of time) of developing the visual novel itself.

After gameplay, participants took part in a discussion during which they shared their opinions on how the narrative structure could have been more detailed if they were the main character himself. In many ways, this post-gameplay discussion was just as—if not more—critical as the gameplay itself. This is because reflection on the experiences of the externalised, in-game persona provides the basis for players to develop an understanding of themselves as the generalised persona. This understanding develops as players reflect on and reflect back the consequences—arising from actions taken by the externalised other in the game world of the visual novel—on themselves.

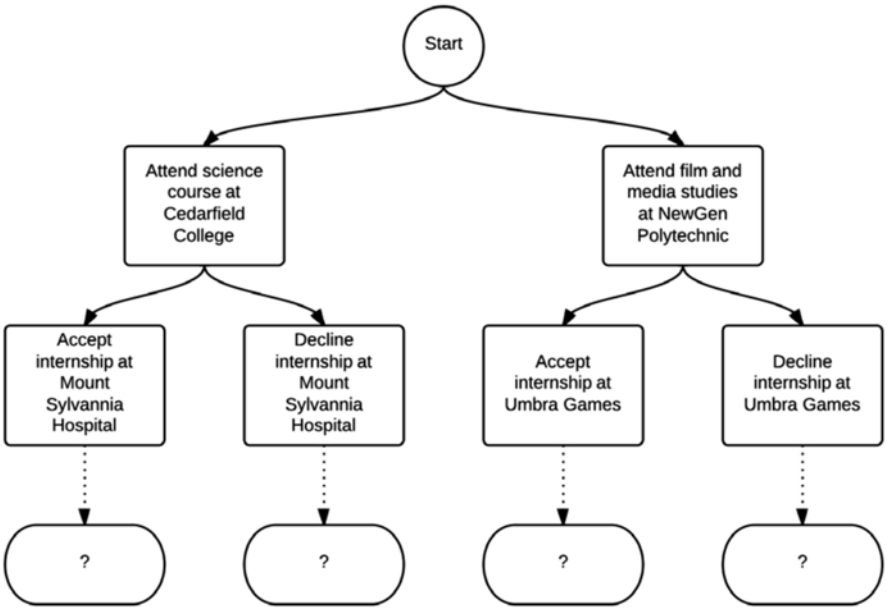

Fig. 11.3 Deliberately rudimentary bifurcating structure

The discussion thus provided the participants with a platform to surface their intuitions about adolescence as a stage of life and how decisions made during adolescence might potentially have long-term impacts in general. For example, when asked about which path would lead to a more successful future for Dan, some of them felt that Dan following his passion was the most important part which would determine whether or not he would succeed in what he does. In this case, the visual novel did not offer a politically correct answer, but the post-play dialogic discussion allowed the player to decide what the most appropriate option would be if he/she were Dan.

Thus, the rigidity of the storyline and limitation of the player options allowed the introduction of cognitive dissonance to the players, after which it was addressed during the post-gameplay dialogic discussion when they voiced their personal opinions.

During the post-gameplay dialogic discussion, players were asked questions which were targeted at the main character's (Dan) life in the visual novel, and the practicality of the visual novel as a potential medium for learning were discussed. It is particularly important to understand that the discussion, together with the visual novel, make up the 'e-workbook' of this study, of which the incomplete nature of the visual novel were used as stimuli for conversation in the discussion. This approach of using the visual novel and the post-play dialogic discussion as an 'e-workbook' is summarised in Fig. 11.4.

Some questions (refer to Appendix) guided the discussion, and the players were encouraged to think critically about the reason and importance of the decisions they

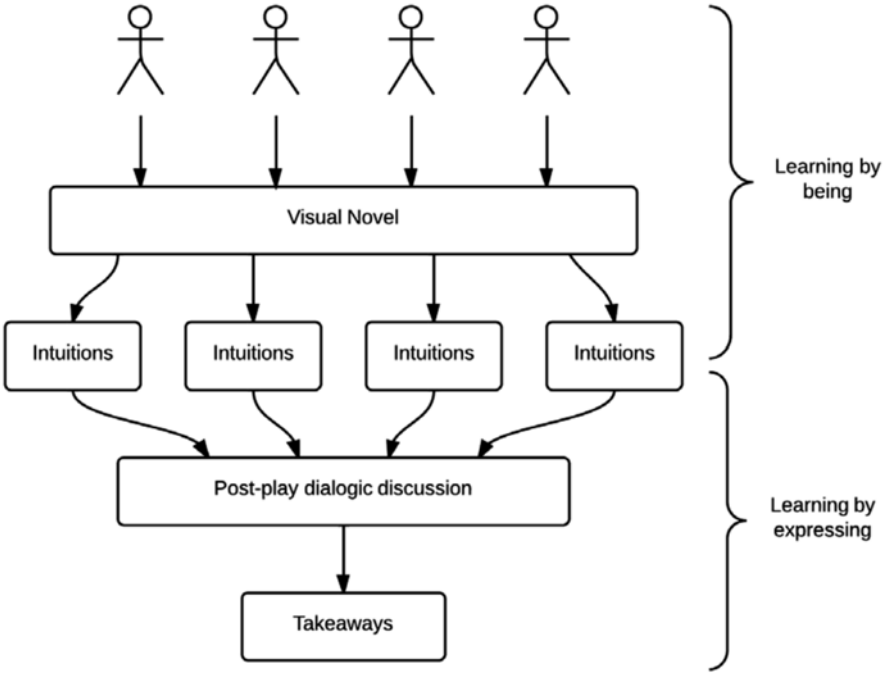

Fig. 11.4 Visual novel and post-play dialogic discussion as e-workbook

had made in the visual novel. This encouraged them to widen their horizons and view a situation from various perspectives, ultimately helping them to make more informed decisions. As one of the participants mentioned, "One decision is not only that junction. It affects everything after that." Hence, by using a visual novel to simulate a possible situation that may stem from their decisions, the visual novel will be able to provide greater insight and knowledge for the players. Another participant mentioned that "…if you make the game more detailed, and more personalised, the game will have more impact." From this, it can be seen that how much impact the visual novel had on the player was also dependent on how personalised the story was. Some of the participants felt that if there was a deeper connection between them and the main character, they would be able to gain greater insight into the story.

The participants also mentioned that compared to the brochures and pamphlets that schools give out, a visual novel was "more interesting" as "it's like a game". Participants found it to be more interactive and preferred visual novels as a medium for such information to be channelled to them. The interactiveness of the visual novel was found to be the most appealing part to the participants, and the abstracted nature of the representation in the visual novel also made it attractive. Thus, the visual novel was found to be a more preferred medium for the dissemination of education-related information.

Conclusion

Through this study, it can be seen that a visual novel can be a suitable medium for learning for other topics with some development. We are by no means seeking to generalise from this proof-of-concept study to the entire educational cohort nationwide. Nevertheless, from the post-play dialogic discussion, it can be suggested that a visual novel is interactive and allows one to view an event from another person's perspective. While there may not be a clear goal that can be reached in a visual novel unlike in games, participants have suggested that it is certainly engaging. This concept of a visual novel as a learning medium has the potential to be used for a wide range of subjects, such as social studies or history, given additional developmental efforts.

In the 2014 Organisation for Economic Cooperation and Development (OECD) report on problem-solving dispositions in teens, adolescents from East Asian economies tended to rank higher than their counterparts in the developed Occidental nations. While this is personally heartening and testament to fundamentally robust education systems in East Asia, good problem-solving skills may not necessarily equate with a rounded appreciation of the contexts of decisions made in adolescents with respect one's potential life trajectories.

As mentioned by the participants, the usage of visual novels as e-workbooks can be translated to younger age groups such as secondary school students between 14 and 15 years of age, or parents, and so on. There are few if any limitations or restrictions to what the context of the visual novel may be about, and which audience it can cater to; in the study described in this chapter, the design decision was made to focus on the narrative of decision making and life-choices during adolescence, but visual novels are essentially open tools. Thus with further development, this may make the concept very versatile and applicable in many areas, as its interactiveness helps to make the learning process more active. In the next chapter, the theme of narratives and storytelling is further explored.

Acknowledgements We are grateful to Nur Afiqah binte Mohd Khalid for providing the artwork for the visual novel.

Appendix: Examples of Questions to Facilitate Dialogic Discussion

- Do you think Dan would be successful in the future after his school life? Why?
- If you were Dan, what would be the first thing to do after JC/polytechnic?
- What are your thoughts about the visual novel you have just experienced?
- What do you think its objectives are/were?
- To what extent do you think the visual novel succeeded in its objectives? How/How not?

- In your preceding response, you made reference to "....". Could you elaborate on what you meant by that? In what way do you think "…" is critical to helping one understand [imputed objectives]?
- Since you see "…" as critical to [imputed objective], how would you go about building it into a similar game narrative?
- What might some of the reasons be behind your design decisions in your hypothetical attempt to help others approach the issue of [imputed objective] in the way you have just recommended?

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Chapter 12
Mathematical Intuition and Storytelling for Meaningful Learning

Young Hoan Cho and Seo Yon Hong

Introduction

For meaningful learning, students need to make sense of new mathematical knowledge based on their existing knowledge or everyday experiences. It is a serious problem that many students acquire inert knowledge that is useful only for school examinations, not for real-world problem solving (Brown et al. 1989). To promote meaningful learning, many educators have made efforts to apply authentic tasks and real-world contexts, which help students to integrate mathematical knowledge with their everyday lives. In anchored instruction, for instance, students construct and use mathematical knowledge in real-world contexts while solving an authentic and complex problem, which is often given in the format of video (e.g. Jasper Adventure Series; CTGV 1992).

For authentic learning in real-world contexts, educators should consider what mathematical intuition students have developed through their everyday experiences and school education. Mathematical intuition can be used to make sense of mathematical knowledge and to solve authentic problems out of school (Ben-Zeev and Star 2001; Birgerstam 2002; Resnick 2006). When a teacher allows students to solve a mathematics problem without direct instruction, students are likely to represent the problem in multiple ways and flexibly explore diverse solutions based on their prior knowledge and intuition. Although intuition sometimes leads to wrong answers, a teacher should encourage students to actively use their intuition in representing and solving mathematical problems because the failure experience can be productive for meaningful learning (Kapur 2012).

Despite the importance of mathematical intuition, few studies have been conducted to provide instructional design principles on how mathematical intuition can

Y.H. Cho (✉) • S.Y. Hong
Seoul National University, Seoul, Republic of Korea
e-mail: yhcho95@snu.ac.kr

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be used for meaningful learning in mathematics. This chapter intends to explore two instructional design approaches based on the nature of mathematical intuition (a) intuitive instruction and (b) Learning by Intuiting. The former highlights the role of a teacher to design instruction on the basis of students' intuitive knowledge, whereas the latter emphasises active participation of students in using intuition to solve authentic problems. In regard to the two approaches, this chapter describes storytelling practices, which are recently emphasised in Korean mathematics curricula. Stories provide real-world contexts that encourage students to use their intuitive knowledge and everyday experiences for understanding mathematical concepts and solving mathematics problems.

The Nature of Mathematical Intuition

Conceptualisations of Mathematical Intuition

Mathematical intuition can be understood as the immediate and implicit cognition of mathematical objects, which occurs without conscious and analytical reasoning (Ben-Zeev and Star 2001; Giardino 2010). It is a self-evident and intrinsically credible phenomenon that does not require any further rationalisation or justification in accepting some mathematical facts (Ebersbach and Wilkening 2007; Fischbein 1987; Giardino 2010). In addition, mathematical intuition is different from insight in that the former takes place almost instantaneously while the latter accompanies a conscious process of problem solving and an incubation period (Hodgkinson et al. 2008).

We can make distinctions between intuitive knowledge and intuiting. Intuiting refers to the cognitive process involved in understanding mathematical objects, solving problems or justifying mathematical facts, whereas intuitive knowledge is the information or the understanding acquired. For instance, research has demonstrated that the intuitive knowledge about numbers and elementary arithmetic, such as addition and subtraction, is universal in all cultures (Dehaene 2009). In addition, humans, before knowing how to count and perform calculation, are able to compare and discern the quantities of visually presented objects. In Ebersbach and Wilkening's study (2007), children have demonstrated their ability to intuit an estimation task. In the study, children aged between 7 and 13 were asked to estimate the exponential reproduction mechanism of water plants. The results showed that the children were able to produce estimations by using their intuition of functions even though they had not yet been introduced to the concepts of non-linear functions at school. Since intuitive knowledge and intuiting go hand in hand, we would like to use the term 'mathematical intuition' in this chapter to include both intuitive knowledge and intuiting in mathematics.

The existing literature suggests that there is no universally accepted view on the origin and development of mathematical intuition yet. Supporting a view that intuition is innate are the classical intuitionists who believe that intuition is not

learned nor developed (Ben-Zeev and Star 2001). Neuroscience research also suggests that the numeric intuitions, in particular, are related to a specialised cerebral subsystems in the intraparietal sulcus (Dehaene 2009).

Others suggest that mathematical intuition is the product of previous experience and interaction with people and the environment (Ben-Zeev and Star 2001). Mathematical intuition is developed from repeatedly experiencing certain mathematical phenomena and finally perceiving the common properties of those experiences. Moreover, Fischbein (1987) identified two types of intuitions depending on how each one develops. Primary intuition naturally arises from experience and is developed independently of formal instruction, whereas secondary intuition is learned from instruction, exploration and experimentation (Ben-Zeev and Star 2001; Fischbein 1987). This latter perspective that mathematical intuition can be developed or learned has important implications for educational researchers. That is, it is necessary to investigate the roles of primary and secondary intuition as well as how we can address and develop learners' intuition in the classroom.

Roles of Mathematical Intuition

Mathematical intuition certainly exists regardless of whether we are aware of it or not, and mathematical intuition influences the process of thinking and learning in various ways. Learners' mathematical intuition may contain naïve or biased beliefs that are used without confirming their validity. Because intuition is strongly trusted by the person, naïve mathematical intuitions can lead to mathematical errors unless used with scrutiny. Mathematical intuition can also result in errors if it is applied improperly without considering the conditions in which it is being used. Some examples of errors caused by mathematical intuition are subtracting a smaller number from a larger number in two-digit subtraction, ignoring the base of the percentages, and doubling the sides of a square to double its area. The errors as shown in these examples do not occur intentionally. Rather, one uses his or her intuition very naturally. Therefore, if the intuition contains misleading beliefs or if the intuition is used improperly, it may result in errors.

Despite the aforementioned imperfections, mathematical intuition can facilitate meaningful learning of mathematics by connecting it to what we already know. This role is important in mathematics education because mathematics frequently involves abstract formulae and symbols. If mathematics is learned by rote, it will carry little meaning nor will it be effectively used by learners. Since mathematical intuition includes what learners already know before entering the school, it can serve as a basis for learning formal mathematics (Carpenter et al. 1996). Instead of understanding mathematical concepts rationally, mathematical intuition can help learners to see and make sense of what the concepts really mean. For instance, intuition on numbers can help learners to comprehend the principles of addition and subtraction (Resnick 2006). Moreover, mathematical intuition can be used as a mechanism to support real-world problem solving. The ability to intuit is important in real-life

situations where many unknown and unexpected variables are present and what we know is sometimes insufficient. Therefore, it is important that students learn to use their mathematical intuition that can help to make decisions (Birgerstam 2002).

Acknowledging these roles of mathematical intuition, several researchers have highlighted the importance of engaging learners' intuition in learning mathematics as it will support understanding mathematical concepts and formulae that are non-intuitive, but abstract and symbolic (Birgerstam 2002; Cheng and Brown 2010; Feferman 2000). If learners learn mathematics only at a conceptual level, they have difficulty applying what they learned (Outhred and Mitchelmore 2000). Because of this, Leinhardt (1988) suggested that learners' intuitive knowledge and formal knowledge should converge as competence increases, which will prepare a base for successful problem solving. In fact, in the study by Cheng and Brown (2010), the students who connected intuitive knowledge and formal knowledge were better able to construct coherent and sophisticated explanations for a phenomenon which they had not learned in school. Others who relied only on either intuition or formal knowledge produced tentative and illogical explanations.

Two Instructional Approaches Based on Mathematical Intuition

How, then, can we incorporate mathematical intuition in a classroom? Two approaches are identified from the existing research on intuition. The first approach is intuitive instruction where an instructor needs to design instruction by considering learners' intuitive knowledge as well as the potential sources of errors. Decontextualised and symbolic concepts of mathematics are often non-intuitive (Tirosh 1999). Therefore, it is important that instructors try to anticipate the difficulties that learners may experience and to present concepts in a more intuitive way. For instance, the concept of area as defined by mathematical formula involves multiplication. However, learners can also understand from experience that an area is covering a shape with unit squares or circles and thus the product of adding unit squares or circles. Outhred and Mitchelmore (2000) suggested that this gap between learners' intuitive knowledge and formal knowledge can prevent deep understanding of mathematical concepts and hence should be closed. One possible method to close this gap is to provide realistic contexts. Research has shown that when given word problems rather than symbolic problems, learners were able to solve the problems more intuitively (Carpenter et al. 1996). Presenting learning contents within a context has also shown to improve learners' ability to understand mathematical knowledge as shown by enhanced performances on the transfer tasks (Casey et al. 2008).

The importance of learning mathematical concepts in a context is demonstrated clearly in Sherman and Bisanz's study on learners' understanding of the equal sign (Sherman and Bisanz 2009). In the study, a group of second-grade students were taught the concept of equivalence either in the symbolic or non-symbolic condition.

In the symbolic condition, the instructor showed a numerical equation, such as $2+3=1+\_\_$. Then, the students were told to write a number in the blank so that when the numbers on the left side of the equal sign are put together, they will be the same as on the right side of the equal sign. In the non-symbolic condition, the instructor used the manipulatives, such as a cardboard and wooden blocks, to represent the equal sign and numbers. The rest of the instruction for the non-symbolic group followed the same procedure. The test results showed that the students in the non-symbolic condition solved twice more problems correctly than those in the symbolic condition. They also justified their solutions accurately three times more often than the students in the symbolic condition.

The results show that the students developed different understanding of the equal sign due to the presence or the absence of symbols. The students in the symbolic condition, which is an unintuitive way of teaching, understood the equal sign as a signal telling them to add all the numbers or to put the answer after it. Because the instruction was decontextualised and detached learners' experiences, the students were not able to make sense of the concept of equivalence—that the two sides should have the same number—but developed rather abstract and inert knowledge of the equal sign. In contrast, the students in the non-symbolic condition were able to gain more useful and meaningful understanding from the instruction that explained mathematics in a more intuitive way. The results of this study indicate the importance of intuitive instruction which connects new knowledge to learners' experiences and embeds mathematical concepts in context. In fact, according to the researchers who study situated cognition, all knowledge cannot be separated from the activity and situation it was created in (Brown et al. 1989). They also highlight the importance of authentic activity and contextualised problem solving, from which students will learn to think like a mathematician and acquire meaningful knowledge.

The second approach to integrating mathematical intuition is to have learners learn by intuiting. In this learner-centred approach, learners will be engaged in such intuitive activity as solving a problem, discovering mathematical procedures, and reflecting on their problem solving process. Wittmann (1981) emphasised the importance of learning activities. It is through the engagement in activities that learners acquire intuitive experiences. Ebersbach and Wilkening (2007) also mentioned that it is important to consider the nature of activities. Performing numerical calculations does not elicit mathematical intuition. Instead, learners need to be given a chance to use and express their intuitive knowledge. One example is found in the cognitively guided instruction (Carpenter et al. 1996). In the instruction, learners were engaged in mathematical problem solving while using physical blocks for direct and concrete experiences of mathematics. Moreover, learners were encouraged to reflect on and describe their strategies to problem solving throughout the task. The researchers emphasised that these verbal reflections of the procedures help students make the connection between formal mathematical knowledge and their intuition gained from experimenting with the blocks.

The theoretical framework of the Learning by Intuiting approach can be found in constructionism. Constructionism is a theory of learning and instruction which shares with constructivism the fundamental assumption that knowledge is constructed

by learners rather than being transmitted (Papert and Harel 1991). Particularly, constructionism emphasises the importance of learners' engagement in constructing artefacts such as a water dam model, a wind power generator and a building in virtual world (Ackermann 2001; Lindh and Holgersson 2007). It is during this process of construction that meaningful learning occurs. Papert (1980) has been a leading researcher in this area, particularly for his works on LOGO. With LOGO, learners can control the movement of a turtle producing various geometric shapes and designs. During this process, learners would have to intuit their ways, using mathematics to calculate how many steps to move and which direction to move the turtle. Similar to Papert's LOGO program, Lindh and Holgersson (2007) investigated the use of programmable Lego robots in a classroom. Students constructed various artefacts using the provided Lego robot construction kits for 2 h each week. After 1 year, the researchers administered a mathematics test similar to the national test. The results showed that students with mid-range scores particularly benefited from learning with the Lego robots. As illustrated in these instances of constructionist learning activities, students can learn mathematics by intuiting. For meaningful learning, students need to be actively engaged in Learning by Intuiting as well as reflecting on their learning process.

Storytelling in Mathematics Education

The Importance of Storytelling in Education

As the most natural and fundamental way of meaning-making, storytelling is used in various fields of education. Stories, which consist of a plot about a person or an object, organise and present information or ideas within a contextualised structure (Casey et al. 2008; Park 2012). In the instructional design field, stories have been used frequently to facilitate meaningful learning as well as to support authentic problem solving. Jonassen and Hernandez-Serrano (2002) emphasised that the importance of using stories as problems for constructivist learning environment because stories are more likely to elicit and connect to learners' past experiences. According to case-based reasoning, people tend to store knowledge in the form of stories and retrieve these past experiences when confronted by a problem (Aamodt and Plaza 1994). Such problem solving process, which rely on experiential knowledge stored as stories in the memory, can be frequently observed among experts (Jonassen and Hernandez-Serrano 2002).

A number of researchers have emphasised the importance of storytelling for meaningful learning because of the following reasons. Firstly, stories present concepts or problems within a context so that learners can make a connection between what they learn and what they experience in real life. This way, storytelling can make mathematics more accessible and bridge the gap between formal knowledge and real-life experiences (Walkington et al. 2013). Secondly, storytelling positively affects learners' motivation and task involvement. Through storytelling, learners are likely to pay greater attention and participate in a more challenging activity

(Casey et al. 2008; De Bock et al. 2003). Thirdly, storytelling can help to store knowledge as stories that can be effectively retrieved and used for problem solving (Jonassen and Hernandez-Serrano 2002). Instructors can provide students with success cases of others to facilitate ill-structured problem solving in a constructivist learning environment. Lastly, from generating a story of their own, learners can develop creative and intuitive thinking. When learners are given a storytelling task, they generate a variety of different stories using their experiences as well as imagination (Sadik 2008).

Recently, the government of South Korea announced its reform plan to apply storytelling in mathematics education. The purposes of the storytelling curriculum are to promote an in-depth understanding of mathematics, to increase students' interest in mathematics and to cultivate thinking skills through mathematics education (Ministry of Education, Science, and Technology 2012). Until 2014, new storytelling mathematics textbooks have been distributed among the first through fourth grades in elementary schools as well as the first and second grades in middle schools. The instructional and learning strategies to apply storytelling in mathematics include the following five types (1) history of mathematics, (2) real-life context, (3) disciplinary convergence, (4) decision making and (5) tool utilisation (Kwon et al. 2013). The following sections present some examples of these storytelling strategies used in mathematics education in South Korea in regard to intuitive instruction and learning by intuiting.

Intuitive Instruction Through Storytelling

Of the aforementioned storytelling types of instructional strategies, 'history of mathematics', 'real-life context' and 'disciplinary convergence' highlight the role of an instructor in intuitive instruction. In order to facilitate meaningful learning, an instructor needs to consider how to introduce mathematical concepts and principles more intuitively. To do so, an instructor can place mathematics in various familiar and interesting contexts of history, real life or other subjects so that learners will be able to build the connections between mathematics and their prior knowledge and experiences. From such intuitive instruction, learners can make sense of new mathematical knowledge intuitively rather than abstractly. We will review each of the storytelling strategies for intuitive instruction and provide several examples of their use in South Korea.

The 'history of mathematics' type of storytelling introduces mathematical concepts with a historical account of how mathematicians developed the concepts or how they were used for solving real-world problems in the past (Ministry of Education, Science, and Technology 2012). Stories are likely to include a mathematician as a narrator of the story, a situation that led to the discovery of a mathematical concept or a mathematical problem from the history (Kwon et al. 2013). For instance, in the unit of linear equation, a short story was written on how the linear equation was used during the seventeenth century in South Korea: "Hong Jung Ha, a mathematicians during the Joseon Dynasty, searched to find solutions for problems like transporting food, calculating interest, and trading, by using the

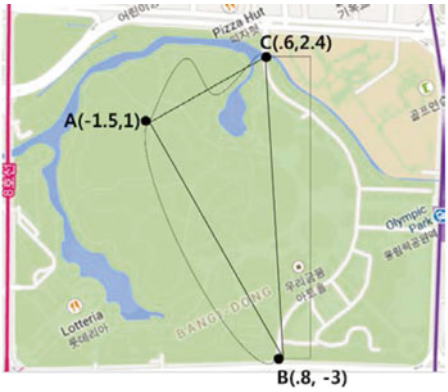

Fig. 12.1 Example of a problem in real-life context

principle of linear equation (Woo et al. 2013, p. 111)[1]." The purpose of this strategy is not only to familiarise learners with historical events in mathematics but also to present the experiences of mathematicians so that learners should be able to see the logic behind mathematical concepts (Freudenthal 1973; Kwon et al. 2013).

The 'real-life context' type of storytelling integrates mathematical concepts and principles with various topics that learners experience in real life (Kim et al. 2013). Using topics from diverse sources including social phenomena, news reports, literature and everyday experiences, this storytelling strategy intends to connect mathematical concepts to learners' intuitive knowledge previously acquired through personal experiences. The storytelling about a familiar topic also helps learners to recognise the practical usefulness of mathematics (Kim et al. 2013). For instance, the following excerpt from a Korean middle school textbook intended to encourage learners to look for regular polygons around everyday lives.

> The cells in a beehive usually consist of regular hexagons. Why are they regular hexagons? Of the regular polygons, regular triangles, regular squares, and regular hexagons can be arranged to cover a plane without overlapping. In particular, by using regular hexagons, we can cover the largest area. We can easily see that the area of a regular hexagon is larger than a regular triangle and a regular square by comparing each shape made from the same length of string. So by having the shape of regular hexagon, a beehive can have a structure that is efficient to store honey and to keep eggs. Regular hexagons can also found in ice crystals and eyes of dragonflies. Let's explore to find more examples of regular polygons in our surroundings or the nature (Woo et al. 2013, p. 277).

In addition to introducing mathematical concepts, the real-life context strategy can also be used to present mathematical problems within a familiar context. For instance, Kim et al. (2013) designed a learning task using the map of the Olympic Park in Seoul (see Fig. 12.1). On the map, various locations were written in coordinates, and learners were asked to calculate and compare the distances between the locations to find the shortest path. Such use of storytelling to embed a mathematical problem in a familiar context can enhance learners' task engagement since the task is perceived more achievable (De Bock et al. 2003).

[1] Storytelling examples in the section, storytelling in mathematics education, were all translated from Korean to English.

The artwork on the right is an example of paintings by Mondrian, a famous Dutch modern artist .He is known for his abstract painting style using horizontal and vertical lines. All of the quadrilaterals in the painting are rectangles. Find and mark all the right angles formed by blue intersecting lines.

Fig. 12.2 Example of disciplinary convergence

The 'disciplinary convergence' type of storytelling focuses on combining mathematics with different fields of studies such as humanities, social sciences, natural sciences and engineering (Ministry of Education, Science, and Technology 2012). This strategy aims to develop creativity and interdisciplinary knowledge in learners by developing tasks that involve mathematics and different subjects (Kwon et al. 2013). Examples suggested by Woo et al. (2013) include that of an instructor integrating mathematics with art by showing how learners can draw a pinwheel or a flower by using different graphs of linear and quadratic functions, as well as that shown in Fig. 12.2, which asks learners to find right angles in a famous artwork.

The essence of intuitive instruction is to introduce mathematics intuitively by relating it to learners' previous knowledge and experiences. The intuitive instruction is particularly important in mathematics education because many mathematical concepts and principles are abstract and symbolic in nature unless presented in contexts (Tirosh 1999). Learning mathematics without contexts can result in inert knowledge, which is less likely to be effectively used for real-life problem solving (Brown et al. 1989). Therefore, in order to support meaningful learning, an instructor should consider presenting mathematical concepts and principles more intuitively by placing them in contexts of history, real life or other domains.

Learning by Intuiting with Stories

Storytelling can also be used for Learning by Intuiting. The Korean mathematics curriculum involves the storytelling types of 'decision making' and 'tool utilisation.' Both activities require students to be actively engaged in intuitive thinking through solving real-world problems and creating artefacts with mathematical tools. In the 'decision making' type of storytelling, students solve a real-world problem about social issues such as environmental pollution, human rights and world peace by applying mathematical concepts, principles and methods (Kwon et al. 2013). For instance, the following excerpt from a geometry unit has secondary school students make a decision on the design of oil tanks. Students need to decide which oil tank is more beneficial or economical between cylinder-shaped and sphere-shaped tanks. After making a decision, students need to share their decisions and the mathematical rationale behind them.

> When we design products, we need to make economical decisions. We can make economical decisions by minimizing the cost of production or by maximizing the benefits from the

> same resource. Most of the tanks to store oil have either cylinder or sphere shapes. The tanks with the same surface areas cost equally for production and maintenance. If there is a cylinder-shaped tank with the base of radius *r* and a sphere-shaped tank with radius *r*, which of the two tanks will be more economical to build? (Woo et al. 2013, p. 311).

The problem above can be integrated with hands-on activities so that students are more engaged in intuitive thinking. A teacher can ask students to design the oil tank with computer software (e.g. SketchUp) and create its prototype with a 3D printer. Students can design a variety of oil tanks with the same resource and compare them in regard to how much oil can be stored. It is possible that students actually measure the amount of water that can be stored in the oil tank prototypes. This hands-on activity allows students to intuitively use their mathematical knowledge and everyday experiences while designing, comparing, modifying and remixing different shapes of oil tanks.

The 'tool utilisation' type of storytelling involves design and modelling activities with technologies such as graphing calculators, computer simulations and 3D printers. Students are engaged in mathematical intuiting while creating, revising and remixing their artefacts, which are mathematically meaningful, with tools. Kim and Kwon (2011) had secondary school students develop a Web 2.0 map (http://kimsangmi.tistory.com) that includes mathematical stories in real-world contexts. In this activity, students explored mathematical concepts and principles in their everyday lives like a shopping mall, a playground, a school and a kitchen. Students took photos of objects that were mathematically meaningful. Next, they developed the Web 2.0 map by adding the photos on the map along with the notes about mathematical concepts or principles behind the photos (see Fig. 12.3).

When making a container, it should use as little material as possible, but be able to hold a large amount of liquid. With the same amount of material used, we should make a container with a large capacity.

Let's calculate and compare the area of a circle and the area of some regular polygons. A square with the area of 100cm^2 has the perimeter of 40cm. An equilateral triangle with the same area has the perimeter of 45.6cm. But a circle, also with the same area, has the circumference of only 35.4cm.

So, compared to a square and an equilateral triangle, a circle has the shortest circumference. Of the containers that have the same height and can hold the same amount of liquid, a cylinder-shaped container will use the least amount of material for building its side. This is why many liquid containers, including a gasoline tank and a thermos bottle, have cylinder shapes.

Fig. 12.3 Example of mathematical storytelling by a middle school student

Fig. 12.4 Mathematical storytelling map

When students posted their own stories in the Web 2.0 map, the stories were automatically shared with other students. They were able to identify who created a story and where a photo was taken from the shared map (see Fig. 12.4).

Through activities of Learning by Intuiting, learners can recognise that mathematics is closely related to their everyday lives, which may increase students' intrinsic motivation and self-efficacy in mathematics education. Learners can also develop competencies to use mathematical concepts and principles as tools to explain what they notice in real-world contexts. According to Brown et al. (1989), "people who use tools actively rather than just acquire them, by contrast, build an increasingly rich implicit understanding of the world in which they use the tools and of the tools themselves" (p. 33). The mathematical storytelling activities, particularly Learning by Intuiting, enable learners to develop and use their mathematical intuition while using mathematical knowledge as a tool in real-world contexts.

Conclusion

Although people often encounter mathematical phenomena or problems in their everyday lives, they are not likely to use their mathematical knowledge acquired in school to understand the phenomena and solve the problems. To address this inert knowledge issue, educators and researchers should pay more attention to mathematical intuition. The mathematical intuition plays an important role not only in making sense of new mathematical knowledge but also in solving real-world problems based on mathematical concepts and principles. To enhance mathematical intuition in school, we have suggested two instructional approaches, intuitive instruction and Learning by Intuiting and provided storytelling examples in regard to each of the approaches. Although both approaches emphasise the importance of mathematical intuition, the latter focuses more on student-centred learning activities, which occur in formal and informal settings, than the former.

More research is necessary to explore the nature of mathematical intuition and to develop instructional models or strategies that promote using mathematical intuition to carry out authentic tasks. To serve the purpose, design-based research (Barab and Squire 2004) should be carried out iteratively and collaboratively in real-school contexts rather than experimental laboratories. For instance, researchers can iteratively apply different types of storytelling in school so as to investigate the role of storytelling for meaningful learning in mathematics as well as to improve learning and teaching practices through storytelling. In addition, mathematical intuition-based learning activities need to be designed, implemented and assessed on the basis of scientific findings about the nature of mathematical intuition (Ben-Zeev and Star 2001; Dehaene 2009). Particularly, more attention should be paid to assessment of what intuitive knowledge students have in the domain of mathematics and how well students use their mathematical intuition for solving a problem, making sense of new knowledge or explaining a phenomenon in real-world contexts. The intuition-based learning and instruction may not be more successful than traditional exam-oriented practices unless competencies closely related to mathematical intuition can be assessed in valid and reliable ways (e.g. Kirschner et al. 2006).

Lastly, teachers need to understand the role of intuition in mathematical education and to improve their competencies for intuitive instruction and Learning by Intuiting. This chapter has included several examples of how storytelling can be used intuitively in mathematics education. The pedagogical innovation can be successful only when teachers are able to help students to integrate their intuitive knowledge with new mathematical concepts or principles through storytelling activities. Otherwise, students may try to memorise step-by-step procedures to solve storytelling problems effectively in high-stakes examinations. Thus, further research on teachers' professional development is as much important as the development of new instructional or assessment methods based on mathematical intuition.

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Part III
Coda

Chapter 13
Disciplinary Intuition as Praxis: The Role of Intuition in Social Education

Mark Baildon

> *… The mind can proceed only so far upon what it knows and can prove. There comes a point where the mind takes a leap – call it intuition or what you will – and comes out upon a higher plane of knowledge, but can never prove how it got there. All great discoveries have involved such a leap.*
>
> (Albert Einstein)

Introduction

In this chapter, I examine how the concept of Disciplinary Intuitions can be enacted in social education. I draw on the work of the French philosopher Henri Bergson to develop a notion of Disciplinary Intuitions that can be useful as an approach to teaching. This conception of Disciplinary Intuitions emphasises the role of experience and intuition as foundational for learning in the disciplines of the humanities and social sciences. The idea of Disciplinary Intuitions highlights the value of immersing young people fully in social experiences and the tensions or problems that are fundamental to living in society.

I begin by outlining some useful perspectives for understanding Disciplinary Intuitions, including Bergson's views of intuition, and then outline some key reasons educational practice needs to give greater emphasis to experience and intuition rather than reified forms of disciplinary knowledge. This makes possible a view of disciplinary experience and intuition as necessary prior stages of educational practice in the disciplines and subject matters central to social education. I also offer an initial overview of what Disciplinary Intuitions might look like in social studies classrooms.

I then provide a brief example of Disciplinary Intuitions in a social studies classroom. This example offers a concrete example of teaching that begins with a focus on experiential immersion to provide students with opportunities to fully engage in and

M. Baildon (✉)
National Institute of Education, Singapore, Singapore
e-mail: mark.baildon@nie.edu.sg

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make meaning of social experience. This suggests that curriculum and instruction should provide greater opportunities for authentic experience and then guide students to examine experience as a way to help them develop disciplinary understanding.

I conclude by arguing that more time in curriculum and in classrooms needs to be given for disciplinary experience and Disciplinary Intuitions in social education. As Roy (2005a) argues, "Intuition offers to educators a praxis for regaining a spontaneous momentum in themselves and, by extension, in the educational experience they create" for their students (p. 448).

Useful Perspectives to Understand Disciplinary Intuitions

Psychological studies of intuition point to diverse definitions, a range of methodological issues related to the study of intuition and a lack of conceptual clarity about what intuition is in different domains (Hodgkinson et al. 2008). Noddings and Shore (1984) note that intuition has long been of interest to philosophers and scholars and they similarly highlight a range of conceptualisations in the field. If we look across this work in psychology and philosophy, we find that the range of definitions have some common defining characteristics that view intuition as a receptive capacity; as direct, non-conscious or pre-reflective knowledge; as a holistic and associative process; as awareness at a bodily, sensory or affective level and as perceptual ability that initiates meaning. Since the study of intuition in psychology is underdeveloped (Hodgkinson et al. 2008) and does not necessarily seem more advanced than investigations in philosophy, I draw on work in philosophy and other fields to provide some productive insights for educational practice.

Similar to psychological studies that see intuition and rationality as "opposite ends of a common bipolar dimension" (Hodgkinson et al. 2008, p. 8), Noddings and Shore also distinguished two domains of intuition—the perceptual and conceptual. These two poles can be seen as residing along a continuum of human information processing (from a psychological lens) or of making meaning of experience (from a philosophical or phenomenological lens). It is useful to see intuition and the conceptual or analytical as two ends of a pole in the disciplines as well. Just as Dewey (1902) argued that the child and the curriculum can be seen as two ends which define a single process, seeing intuition and the analytical–conceptual as two ends of making meaning in the disciplines can be productive for educational purposes.

Disciplinary Intuitions, then, can be viewed as a capacity held by disciplinary experts who have developed certain automaticity and are able to gain sudden insights, recognise patterns or immediately sense the significance and structure of a problem due to their immersion, deep experience and longstanding learning in a particular disciplinary domain. As Hodgkinson et al. (2008) find, an "expert's intuitive ability is also derived from their capacity to recognize salient environmental cues and rapidly match those cues to commonly occurring patterns, responding in ways that lead to effective problem solving and decision making" (p. 7). Disciplinary expertise can lead to hunches or hypotheses leading to new insights and understandings

in the discipline. Or, as Noddings and Shore (1984) argue, "Generally, the people most knowledgeable in an area are those who have the most frequent and the most reliable intuitions" (p. 64).

However, there is another view of intuition as a more innate and natural capacity of humans. There is a great deal of evidence that all humans have some capacity for intuition and that "intuitions are not all dependent upon extensive past experience in the given field" (Berne 1977, p. 26; as cited in Noddings and Shore 1984, p. 28). Intuition is a form of knowledge based on direct experience and not necessarily dependent on rational thought (Rowan 1986). It is the capacity for direct knowledge without logical inference (Sadler-Smith and Shefy 2004) and exists at the experiential and pre-conceptual level. It does not necessarily depend on disciplinary knowledge. It is these views that have the most in common with the views of French philosopher Henri Bergson who devoted a great deal of his work on the study of intuition.

This type of intuition can be seen as disciplinary in the sense that it is foundational for learning and developing knowledge in the disciplines that have traditionally made up school subjects. Again, Dewey (1902) helps us see that the child's experience contains many of the elements and interests that constitute the disciplines. The child's experience and intuitive capacity can be an educative pathway to disciplinary understanding. If we want young people to develop some level of disciplinary knowledge and skill (in school subjects), we should see their experience and intuition as significant starting points.

In a chapter on the disciplines of geography and history in *Democracy and Education*, Dewey (1916) argues that these disciplines developed from the spatial and temporal problems central to living in society. Dewey goes on to argue that, "it is the nature of an experience to have implications which go far beyond what is at first consciously noted in it. Bringing these connections or implications to consciousness enhances the meaning of the experience" (p. 217). For Dewey, history and geography are about enlarging the significance of direct social experiences by helping students make meaningful connections. Conceptualising certain kinds of experience and intuition as disciplinary, then, can be the ground from which meaningful disciplinary connections might be made.

This idea of disciplinary intuition can help us focus on the role of experience in learning. It is when we start to sense, intuit, feel and experience what Dewey (1910, 1938) referred to as felt problems that we begin to enter into the disciplines as organic and dynamic ways of knowing. For Dewey (1910), "Instruction in subject matter that does not fit into any problem already stirring in the student's own experience, or that is not presented in such a way as to arouse a problem is worse than useless for intellectual purposes" (p. 199). It is the deep investigation of felt problems that gave rise to the disciplines.

As Britzman (1991) points out, Dewey's concern was with the "work of shaping and interpreting experience, and whether such interpretations lead to transformative knowledge about the self and the social world" (p. 34). Unfortunately, this intimate relation between experience and knowing is not typically respected in academic settings. This is why thinking about the role of intuition in education is so important. It restores educational value to experience. It creates possibility for

"deeply absorptive learning" (Roy 2005a, p. 456) and can make us more open and receptive to the qualitative phenomena of experience. Too often, however, we rush to analyse or define experience with concepts. According to Thayer-Bacon (2003) "we find that first concepts become a method, then a habit, and finally a tyranny" (p. 59).

Bergson's Views of Experience and Intuition

If we can see the disciplinary and educational value or potential of experience, we can begin to see the value of particular dispositions and ways of knowing typically associated with intuition. These include the role perception and close observation, affective engagement, tacit knowledge, the sensing of associations or connections and more holistic judgements might play in disciplinary learning and understanding.

This is where Bergson's view of experience and intuition can help us develop the idea of Disciplinary Intuitions as participating in a discipline in a lived manner. Roy (2005a) points to how Bergson's view of intuition allows for a deeper probing of experience as an unfolding, qualitative and ever-changing phenomenon. Roy points to the range of thinkers, from Kant to Polanyi, Kuhn and Wittgenstein, who emphasised the role of tacit knowledge in disciplinary knowledge. These thinkers saw that "there is something vital in cognition that cannot be accounted for by purely rational ways of knowing" (p. 445).

Highlighting the fetish of measurement and accountability that "has had the effect of leaving out whole dimensions of human experience that cannot be measured easily" (p. 448), Roy draws on Bergson's approach to intuition because it offers "a richer and more intimate contact with phenomena… [so that we might] recognize the deepest character of phenomena, which is change and qualitative transformation" (p. 447). Similarly, Bergson's view of intuition can lead to a richer and more intimate view of the learner and the centrality of the learner–experience relationship in disciplinary learning.

Although writing about philosophy, Bergson (1946) wrote that our thinking had become too abstract and that our view of reality consisted of "snapshots…taken of the continuity of movement and duration" (p. 6). The change, flux and continuity of experience are broken up into successive, multiple and distinct ideas in our effort to make meaning of experience. This helps us see the disciplines as subject matter that is retrospectively arranged (after experience) into a collection of concepts that became fixed as disciplinary knowledge. Old, ready-made concepts and formulations based on prior experience are then imposed on new experience. Immediate experience itself often eludes us and is organised or distorted by the reified concepts developed from others efforts to understand past experience.

In the case of the disciplines, these concepts are the substantive concepts that make up a particular discipline. They are typically used as deductive lenses through which past, present and even future experiences can be ordered, structured and understood. For example, in a history classroom, the study of the civil disobediences that shocked post-war Singapore might include order and stability, individual

rights and security as substantive concepts for understanding this period of history. These concepts help us make sense of the past, our experiences and the social world around us. However, they can also serve as blinders. They create a deductive, "abstract and empty unity" of reality and of continuity (Bergson 1946, p. 19). Instead of students having experience and making sense of that experience in all of its peculiarities (Deleuze 1991), the historical or geographic concepts they learn in classrooms are imposed on their own experience. As Deleuze (1991) argues, the Bergsonian method does not go toward concepts. It allows for affectivity, recollection of other experiences in memory and a greater plurality of meanings.

For Bergson, then, intuition is consciousness in immediate experience. It is mind as/in experience. It is an awareness of experience as flow: "a growth from within, the uninterrupted prolongation" blending present, past and future; "the direct vision of the mind by the mind, – nothing intervening, no refraction through the prism" of language or concepts; it is "a knowledge which is contact" (Bergson 1946, p. 20).

Bergson helps us think about intuition as an intimate connection between experience and the experiencer. It consists of a deep engagement with experience that connects us to objects, others and the social world. Bergson saw it is an empirical method in the sense that it is grounded in the immediate data of experience (Bergson 1913). It requires an "entering into" of experience; it is an "integral experience" (Bergson 1913). This view of intuition rejects the duality of mind and matter; it is a theory of pure perception as a way to reinsert life back into itself rather than a reliance on the sterile analyses and detached abstract learning that often characterises education in subject matter.

As Noddings and Shore (1984) note, Bergson believed an object, person or situation could be more deeply understood through intuition than through intellectual analysis. Intuition could yield a pure vision of or connection with experience and allow individuals to draw on more spontaneous or instantaneous thought rather than analytical constructs.

Bergson's Idea of Intuition as Method

To restore the vital role that experience and intuition play in the educational process, it is important to consider Bergson's idea of intuition as method and to draw on thinkers such as Deleuze (1991) and Roy (2005a) who elaborated on his philosophy. For Deleuze (1991), freedom lies in the power to decide problems themselves and Bergson's method started with perception to "perceive things where they are" (p. 25). Intuition leads us to consider the significance and meaning of experience by formulating the problems that will direct our inquiries.

However, Deleuze is quick to note that although intuition leads us to go beyond experience, "this going-beyond does not consist in going beyond experience toward concepts" (p. 28). This is a key distinction. It means that we must reside in the experience itself and draw on our intuition rather than quickly resorting to or relying on disciplinary concepts.

Bergson's method sought to more deeply engage experience as "unceasing creation, the uninterrupted up-surge of novelty" (Bergson 1946, p. 7). His notion of duration was "as a creative evolution" in which there "is a perpetual creation of possibility" (p. 10). He argued that it was "not a question of getting outside of time (we are already there); on the contrary one must get back into duration and recapture reality in the very mobility which is its essence" (p. 19). This suggests being fully attentive and attuned to experience to see things as they *are* without the interference of preconceived notions. For Bergson, this demanded "a new effort for each new problem" (p. 20).

Roy (2005a) argues that Bergson's view of intuition is "a methodological awakening" that "can lead to a richer and more intimate contact with phenomena" (p. 447). For Roy, Bergson's method constitutes a four-part praxis of questioning time, re-evaluating experience, negating finitude and resisting measurement. The first move of intuition as praxis is to develop a different relationship to time; to develop a sense of time as duration, as richly qualitative, as "always a becoming" (Roy 2005a, p. 451). Each moment is unique. Lived time cannot be captured, measured or fully defined.

Bergson's view of time as duration requires one to be fully open to and immersed in the flow of experience to notice its incessant change and heterogeneity. Each moment is different and potentially rich in meaning. This next move, the re-evaluation of experience, requires seeing experience as "multiple heterogeneous sensations flowing into each other that are normally edited out of consciousness" (Roy 2005a, p. 454). It is an attunement to experience as a sense of flow, in which one is fully immersed, engaged and aware in the experience.

The next moves, negating finitude and resisting measurement, are to see experience as being unbounded by language, conceptualisation or measurement. Instead of homogenising experience by imposing on it certain measures of time, measurements of experience or analytical constructs, it is necessary to pay close attention to qualitative difference. This "deepening of our perception of qualitative differences in phenomena [is] a process that leads to the full flowering of intuition" according to Roy (2005a, pp. 454–455). Roy goes on to argue that, "This inexhaustibility in the present, or qualitative change, is also a door to the imagination, as it is a suspension of the usual quantifying and measuring states of the mind that impart a finitude to experience" (2005a, p. 455). Resistance is a necessary aspect of transformation and, as Roy argues elsewhere, resistance to promote learning "means to be in a state of revolt against settled perceptions" (2005b, p. 37).

Implications of Bergson's Views for Disciplinary Intuitions

Directly teaching disciplinary concepts with a focus on accumulated knowledge is difficult to resist in educational practice. So much of curriculum and instruction stresses the teaching of concepts and knowledge within a given timeframe (the class period)

instead of allowing students to experience life, fully attend to experience and investigate the problems that arise from their own experience. We tend to value the specialised theories, concepts and knowledge in the disciplines used to divide the world analytically rather than see experience as whole and of value in its own right. For the subjects of history and geography, we divide the world spatially and temporally instead of seeing ourselves as part of space and time, as existing in the here and now, and as having problems that emerge from experience. This focus on analytical constructs and concepts severs knowledge from experience.

Disciplinary intuition can be seen as existing between direct experience and disciplinary knowledge. This is the origin of disciplines as sensemaking methods and concepts to help us systematically understand the world. However, the disciplines often become reified, rigid and treated as static ideas to be transmitted when taught as school subjects. As Roy (2005a) argues, education is all too often viewed as imparting "finished ideas" rather than cultivating "sensitivity to transition and continuous change" (p. 452). And this is where Bergson "helps open up a field of perception" and think more fully about what "reeducating the senses toward intuition" might mean (Roy 2005a, pp. 453–454).

Bergson (1946) saw intuition as a method for integrating empirical and intuitive knowledge and hinted at what an education aimed at developing intuitive capacity might look like. Noting that, "teaching has remained too verbal" he suggested that students "be invited to observe, to experiment, to work things out for themselves" (p. 68). He protested against "the substitution of concepts for things" (p. 69) and called for greater opportunities for students to engage in focused concentration and the posing of problems based on the tensions that arose in their experience. It was these authentic experiential and existential problems that could fully engage the attention and focus of students. Similarly, Noddings and Shore (1984) argue that, "A continual emphasis on conceptual explanation leads students steadily away from the objects they should be attending to. It satisfies the logic of the subject matter but not the logic of the child" (p. 118).

A notion of disciplinary intuitions can help us restore balance to the educational process. Questioning the time structures that dictate schooling and resisting the measurement and regulation of time to make time for intuition is a necessary first step. More time is necessary for students to have experiences other than the experience of sitting in classrooms and engaging with the pre-defined concepts and static content they are expected to learn. In the humanities, this means teachers need to be able to think about and design experience in ways that bring students into authentic contact with the social world, the past, space and place. A reconstituted notion of time and experience is a necessary aspect of an educational praxis that gives greater emphasis to experience and intuition instead of an almost exclusive focus on order, control and reified bodies of knowledge that are transmitted to students.

We also need to more critically question and challenge the imperative to measure educational outcomes. Disciplinary knowledge as a body of knowledge to be learned can be measured on examinations and tests, perhaps, but other dimensions of learning are not so easily measured. This focus on learning and assessing disciplinary knowledge

has resulted in learning outcomes rigidly driving the educational process. For Dewey (1916), this was one of the fundamental problems of social education:

> The vice of externally imposed ends has deep roots. Teachers receive them from superior authorities; these authorities accept them from what is current in the community. The teachers impose them upon children. As a first consequence, the intelligence of the teacher is not free; it is confined to receiving the aims laid down from above. (p. 104)

This emphasis on externally imposed outcomes and measurement corrupts the educational process. Noddings and Shore (1984) similarly note that curriculum typically makes two mistakes: "first, it establishes specific learning objectives and then asks, 'How can we get people to learn these?' and, second, it unduly emphasizes the general, cognitive, and rational over the concrete, affective, and nonrational" (p. 124).

Intuition as an educational method is an attempt to ground thinking and learning more fully in experience, through a rigorous immersion in and engagement with experience. Noddings and Shore (1984) refer to this as relearning "ways of dwelling on things and in them" (p. 152). Making experience a more central feature of education requires a renewed consideration of the role experience plays in all learning. It requires re-inserting experience into education, to re-establish the *élan vital* that Bergson (1946) wrote about. What Csíkszentmihályi et al. (2005) describe as flow might be one way to help educators rethink experience and student engagement in classrooms. The factors they identify as constituting flow include an intense and focused concentration on the present moment that results in a distorted sense of time and full engagement in the task at hand. One is fully immersed in the experience and the experience is seen as intrinsically rewarding rather than conducted for external rewards (or punishments).

To make intuition an educational method, teachers need to view teaching as a creative process that requires them to deeply understand their learners and the role experience plays in their learning. They need to think of themselves as designers of learning experiences, in which they are able to view the subject matter through the eyes of the learner, as well as understand students' experiences through the lenses of the subject (McDiarmid et al. 1989). In other words, they need to more fully think about the kinds of experiences students can have in subject matter. To see what this looks like in practice, let us now turn to a curricular example.

A Curricular Example of Intuition in Practice

As a social studies teacher, I was always amazed at how my students would seemingly "lose themselves" in simulations that had been well designed. For example, during a Middle East Peace Conference simulation that I designed and used for several years, my students played the role of delegates from various countries to work out a compromise that would be acceptable to all parties to "settle" the various issues central to Middle East conflict. Mainly the simulation focused on

Israeli-Palestinian border issues, Israeli settlements in the Occupied Territories, security issues, water rights and other contentious issues. When doing this with middle school students, they would research these issues and their roles and then passionately participate in intense negotiations that often lasted several class periods. I had similar experiences with other simulations, some of which were commercially packaged. These simulations provided simulated roles and experiences for students to engage with real life issues.

I also noticed students had powerful affective and intellectual responses when conducting certain kinds of field trips, such as student visits to the Holocaust History Museum at Yad Vashem in Israel or to the Tuol Sleng Genocide Museum and the Killing Fields in Cambodia. Visits to these sites were intense experiences in which students came face to face with the past, and these experiences often led to powerful journal entries, discussions and insights on the part of students.

More of these types of learning experiences seem vital to an education that places greater emphasis on students' experiences and the role of intuition in the learning process. Of course, a great deal of preparation is necessary to design these kinds of experiences (in the case of simulations) or to plan powerful field experiences (in the case of field trips). Part of what we can do as educators is to teach students how to engage in those experiences and encourage students' intuitive sensemaking during the experience.

When I taught Humanities at the Taipei American School from 2004 to 2006, the team of Humanities teachers (Social Studies and Language Arts teachers) designed an experiential learning activity that we called the Tien Mu Trek. This trek required students to go into the community of Tien Mu where the school was located to engage in a sensory and observational exercise. This activity highlights some key features of using intuition in educational practice and the ways students can be guided to pay closer attention to experience.

We introduced the activity to our Grade 9 students by emphasising that the project united their English and Social Studies classes "to create a true Humanities experience… [in which they would] become anthropologists and social researchers to observe and write about different aspects of daily life in Tien Mu." The introductory handout encouraged them to use "new eyes" to "observe the activity, appearance, and aromas" of two selected sites in the neighbourhood.

The trek's theme was "Old World meets New Economy" and students were briefed on possible locations in which they could choose to observe (see Table 13.1 below).

On a handout titled, "Tien Mu Trek: Being an Observer," students were instructed to fully experience the place. The handout is reproduced in Appendix. Students were given a note-taking form to "keep track of what you notice" and given two 3-h blocks of time to investigate selected sites. The project handout also noted that students would expected to take photographs at each place, conduct an interview in each site and after thinking about their sensory experience and reviewing their notes they would write a comparative descriptive piece that compared the old world and new economy places. They then had to compile their writing and photographs into a webpage that would make up the final activity for the project.

Table 13.1 Old World, New Economy locations

Topics:	Examples of Old World		Examples of New Economy
Beverages:	Chinese tea house	……..	Coffee shop
Eating out:	Noodle house / stand	……..	Fast food/Western restaurant
Recreation:	Past entertainment	……..	Present/future entertainment
Athletics:	Traditional exercise	……..	Modern/Western athletics
Religion:	A local temple	……..	Christian church
Groceries:	Street markets	……..	Supermarkets
Culture:	Cultural artefacts stores	……..	Shops/malls with trendy stuff
Architecture:	An old building	…….	New, modern building

While this activity does not fully follow Bergson's method of intuition, given the constraints of the school schedule (with class periods) and requirements to give students grades for their work, there are a few elements that are worth highlighting. Firstly, the activity was designed to engage students in a sensory experience outside of the classroom. Secondly, it guided students to focus on the experience itself. The lesson required students to pay close attention to the sights, sounds and smells of their experience. It then provided an open-ended opportunity for students to "work things out for themselves" and to develop their intuitive insights through photographs and a writing activity.

Noddings and Shore (1984) suggest that we can design classroom lessons with intuition in mind by giving students opportunities to look, sense and judge and by encouraging their experimentation to create their own representations. In this activity, we created an opportunity for students to fully experience different social settings, make their own observations (with guidance) and then share their own insights and learning in the form of their photos, writing and web design. Some created very artful representations (e.g. in the form of a poem), others focused more on visual display (in their arrangement of photos and web design), whereas some students provided a more sociological or anthropological account of their observations with insights into what accounted for the differences between the traditional site and the modern site.

We put disciplinary understanding at the end of the project rather than at the beginning (Noddings and Shore 1984) when we debriefed their observations and their inferences about differences between the "old world" and "new economy." By doing this, we gave more focus on having of experience, of full immersion in a social space to carefully attend to social experience, and we empowered students to develop their own intuitive insights about their experience. As Lim notes in this book, we engaged students in everyday environments to stimulate more intuitive insights about those environments and what was happening in them. Although we provided two overarching concepts—"old world" and "new economy"—as lenses, we encouraged students to "really watch" and to "pay attention to" several different dimensions of social experience.

Conclusion

Education has been narrowly guided by a technical-rational ethos of control in which educational outcomes are established by stakeholders far removed from educational processes. These educational authorities tend to devalue experience and intuition to satisfy the logic of the subject instead of the logic of the child (Noddings and Shore 1984). This results in disciplinary knowledge being viewed as a primary end of learning instead of disciplinary methods being viewed as processes of sense-making that include intuitive, analytical and conceptual ways of thinking.

As we seek to draw the various ideas of the preceding chapters to a close, we could do worse than to remind ourselves that Dewey (1910) advocated a form of control that emerged from and within the interactions and experiences of the educational process. This more emergent form of education makes curriculum a living verb (Doll 1993) in which education itself is more attuned to experience and the range of processes used to make sense of experience. This means giving more attention to creating the kinds of disciplinary experiences that will allow students to fully experience social realities, use their intuition to develop their own initial understandings and then be given disciplinary tools and methods that will deepen and expand their understandings into disciplinary knowledge.

A model of practice that might help open educational practice in these ways can be taken from the world of craftwork. Richard Sennett (2008) in his study of craftwork argues that there are three basic abilities that are foundational to craftsmanship—the abilities to localise, to question and to open up. According to Sennett, the ability to localise involves focusing attention, the "capacity to attend to 'here' or 'this'" (p. 278). This is the type of attunement to experience and to the task at hand that spurs intuition. The ability to question "is no less and no more than a matter of investigating the locale…an experience that suspends resolution and decision, in order to probe" (pp. 278–279). It is the kind of deep engagement called for by Bergson and others as a necessary part of learning. The ability to open up is the capacity to

> …draw unlike domains close to one another and to preserve tacit knowledge in the leap between them. Simply shifting between domains of activity stimulates fresh thinking about problems. "Open up" is intimately linked with "open to," in the sense of being open to doing things differently, to shifting from one sphere of habit to another." (p. 279)

Opening up and to something is an intuitive process that enables one to develop connections between areas of knowledge, gain particular insights and think about things in novel ways without the forced imposition of particular categories.

Sennett talks about how a "here and now" focus on experience leads to the deep engagement and sense of flow that psychologists have described. Sennett's view of questioning arising from focal attention is similar to Bergson's idea that "we perceive things where they are" (1946, p. 25) and Deleuze's (1991) notion that this is how problems worthy of investigation are identified.

Throughout this book, we have—as educators—sought to invite you—our fellow practitioners, researchers and readers—to focus more on the role experience and intuition play in disciplinary work. Disciplinary intuitions as praxis means we

need to see curriculum and disciplinary knowledge from the learner's vantage point and design learning experiences that are truly experiences that will open students to an enlargement and deepening of understanding. We need to create learning opportunities that are truly meaningful for learners, help them attend to their experience, guide them to engage meaningfully in experiences that are worthwhile and let them come into authentic contact with social life in its myriad forms. This is where disciplinary problems come from, as well as the empirical data from that we make sense of to better understand social life and ourselves. In the subsequent and concluding chapter of this book, Howe suggests some examples of just such empirical data from her work in the natural sciences.

Appendix: Tien Mu Trek Handout

Tien Mu Trek: Being an Observer

Read the text of these social places. There is always more going on than what's on the surface. Open your eyes to the tone, ambiance and personality of a place by taking the time to really watch what the story of a place is.

Pay attention to:

- *What tickles your senses—sight, sound, taste, touch and smell*. What is your sensory experience? What does it smell like there? What are the sources of the smells? Is it light or dark? Is it quiet? Noisy? Where are the noises coming from? Is it cold? Warm? Humid? Outdoors? Indoors? If there are items/objects you can touch, what do they feel like? If there are things to eat or drink—what do they taste like?
- *Social interactions*. Are people formal or informal with each other? How do they greet each other? Is their conversational chit-chat or is it business only? What social norms appear to govern these interactions? How do people behave? Does there appear to be an expected behaviour? Do some people act out of the ordinary? If so, why? How are they received by others? Do they mingle? Is it crowded? Is privacy expected? Do strangers interact? How much personal space do people have?
- *Signs*. What do they say? What do they show? What language are they in? For whom are they intended? How do they attract people? Looking at images on the signs, what do they tell you about the place? If you cannot read Chinese, what does the sign convey about the place and its purpose? If a sign is in English only, what will a person who does not read English, understand about the place from the images?
- *Use of space*. Is it public or private? Who has access to it? When? Why? Is there a centre that people congregate around? Is it designed for individuals or groups? How do you know?

- *Movement and transportation*. How do people get around and get there? Public transport? Walking? Cars? Scooters? Taxis? What can the modes of transportation used reveal about the people who go there and the place itself? Are people free to move about there or do they stay still? Or is there a schedule of when and how people can move? Are people moving through quickly or do they stay a while?
- *Social groupings and status*. What do you observe about how people present themselves? How are they dressed? For work? Play? Errands? Social meetings? Does their appearance reveal or conceal their social class? Age? Socioeconomic status? How do men and women / boys and girls interact? Is there separation by gender? What relationships (parent / child, boyfriend / girlfriend, colleagues, friendship only, etc.) do you see between the sexes?
- *Architecture and building/location structure/condition*. Is this a new building? Old building? Is it clean? Dirty? Is the design modern or old? Who uses the space? How does the building reflect those who gather there? What are the uses of this space?
- *Things that you do not understand, do not ignore them!* Be ready to ask questions of people who are there who can help you better understand.

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Chapter 14
Misconceptions, Intuitions and Elementary Physics: Harnessing Everyday Understanding in Learning Environment Design

Christine Howe

Introduction

Children's conceptions of physical events have been extensively discussed. Philosophers from Aristotle to Kant have speculated about their form, and Einstein was sufficiently intrigued to persuade Piaget to clarify through empirical research. Amongst physics educators, it has been recognised for many years that the difficulties children experience in mastering the discipline at school stem, in part at least, from the conceptual challenge that the material implies. Thus, charting the relation between school-aged children's conceptions and the received wisdoms of physics has become a significant theme in research (see Duit 2007, for a bibliography with thousands of relevant entries). A range of methodologies has been used, but one of the most popular involves presenting scenarios and asking children to predict outcomes, e.g. anticipate whether 'float' or 'sink' will occur when heavy and light objects are immersed in water. Regardless of topic area, results indicate marked divergence from received conceptions, which often continues beyond school age and into adulthood. For instance, rolling objects are often expected to move with constant (or even accelerating) speed until they lose 'impetus' or hit a barrier, whereupon stopping is instantaneous (Gunstone and Watts 1985; Howe 1998; Inhelder and Piaget 1958; Langford and Zollman 1982; McDermott 1984; Osborne 1980). The gradual deceleration that actually takes place is seldom anticipated. When objects roll over cliffs or fall from moving carriers, their predicted trajectories typically include vertical fall, diagonal fall and horizontal continuation in space prior to a 90° turn and descent (e.g. McCloskey 1983; Whitaker 1983). They rarely encompass parabolic paths that continue forwards in the pre-fall direction as are actually followed.

C. Howe (✉)
Cambridge University, Cambridge, UK
e-mail: cjh82@cam.ac.uk

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Nevertheless, no matter how scientifically unorthodox notions are when used in prediction, there must be a substrate of orthodoxy that allows children to recognise when events do or do not unfold in the normal fashion. Children would not react with surprise to the actions of conjurors or cartoon characters unless they can recognise the incompatibility with habitual events. Surprise reactions to violations of physical reality have in fact been demonstrated very early in life, through observing patterns of arousal (usually via gaze monitoring but sometimes via heart rate) when events do and do not concur with everyday experience. For instance, in a series of studies (Kotovsky and Baillargeon 1994, 1998), scenarios were presented to 6- to 12-month-old infants where rolling cylinders struck initially stationary cylinders with varying degrees of force. Lower arousal was recorded when the distance that the latter cylinders rolled after impact was proportional to force as is naturally the case than when it was non-naturally disproportional. In further studies with a similar age group (Kim and Spelke 1992), scenarios depicting balls accelerating non-naturally when rolling *up* slopes produced greater arousal than scenarios depicting the natural deceleration, as did scenarios depicting balls decelerating non-naturally when rolling *down* slopes compared with scenarios depicting natural acceleration. While an additional 12 studies relating to fall after horizontal motion (i.e. the rolling off cliffs situation) found little differentiation amongst trajectories during infancy (Kim and Spelke 1999), they indicate that well before the end of the preschool period children recognise the naturalness of parabolic fall that continues forwards in the pre-fall direction.

In short then, the predictions that school-aged children (and often adults) make about how physical events unfold indicate knowledge that is riddled with misconceptions. However when similar (and sometimes identical) events are shown to unfold in natural and non-natural fashions, even preschoolers successfully differentiate. Over the years, there have been many attempts to explain this seemingly strange situation, and they usually begin by noting that prediction requires explicit engagement with background knowledge. In other words, scenarios must be related to existing representations, and relations must be considered and used to draw inferences, i.e. engagement is 'deliberate' (Hogarth 2001) or 'reflective' (Plessner and Czenna 2008), and involves 'reflective representation' (Dienes and Perner 1999). By contrast, recognition of naturalness demands only that events be matched with background representations; it 'reflects' rather than 'predicates' the properties of these representations (Dienes and Perner 1999). As such, it does not necessitate consideration and inference, meaning that non-deliberative engagement suffices.

This form of engagement is often referred to as 'tacit' (e.g. Hogarth 2001; Kim and Spelke 1999), but for the authors of many other chapters in the present volume it would be termed 'intuitive'. In the present context, I am happy to use this term too, and from now on I shall refer to the kind of processing that recognition requires as 'intuitive processing'. In any event, the explanatory problem posed by the prediction–recognition gap is typically construed in terms of understanding why intuitive/tacit processing is more successful than explicit.

A range of proposals has been made. At one extreme, there are theorists (e.g. Fodor 1980; Hogarth 2001; Plessner and Czenna 2008) who postulate separate knowledge systems, one system covering explicit processing (including prediction) and the other addressing intuitive processing (including recognition). Roser et al. (2005) data from split-brain adults are supportive of what from now on I shall call the 'two-systems approach', for they suggest hemispheric differences over explicit and intuitive processing. Yet against this, the nature of the systems is seldom pinned down in the two-system approach: famously for instance, Kahneman (2011) postulates an explicit system that is more accurate than the intuitive one, exactly the reverse of what is suggested for the physical domain. At the other extreme, there are also theorists (e.g. Kim and Spelke 1999) who believe that the same knowledge system is involved in both cases, and who attribute the differences in outcome to the fact that explicit engagement is inherently more challenging. In particular, explicit engagement involves relating to existing representations, considering relations and drawing inferences, when intuitive engagement depends upon relating alone. Being more challenging, explicit engagement can, it is argued, result in elements of knowledge being overlooked, hence the associated misconceptions *and* the divergence from what is known intuitively. Supporting what I shall call the 'single-system approach' is the fact that explicit and intuitive processing starts in the same fashion, relating to existing representations. Nevertheless, it is hard to see how task difficulty alone could account for the scale of the explicit/intuitive divergence, in some cases flawed responses in adulthood vs. success in infancy.

Both the two-system and the single-system approach seem troubling from the present volume's perspective. If prediction and recognition call upon the same knowledge system as the single-system approach presumes, it is reasonable to talk about explicit and intuitive *processing* but not about explicit and intuitive *knowledge*. Yet Disciplinary Intuitions relates to knowledge. While the distinction between explicit and intuitive knowledge is part-and-parcel of the two-systems approach, its emphasis upon two autonomous systems suggests difficulties with using Disciplinary Intuitions to promote understanding at the explicit level. In other words, the implications for the design of learning environments could be rather limited.

More encouraging in the present context would be evidence for a compromise position, i.e. partial separation between the knowledge underpinning explicit and intuitive processing but also partial linkage. Compromise positions have been theorised (see, e.g. Carey 2009), but until recently not systematically explored through empirical research. However, four studies that my colleagues and I completed a few years ago not only allowed for exploration but also provided strong support for a compromise approach. In the final chapter of this volume, I summarise the studies in the next section, focusing on the elements of specific relevance to this volume. Later (and with reference to two further studies), I draw out some implications for learning environment design. All six studies were conducted in the UK and funded by its Economic and Social Research Council (Grant: RES-062-23-0240).

Prediction and Recognition of Object Motion

The studies were all concerned with children's knowledge of object motion, for as indicated already previous research had shown that explicit and intuitive processing are both meaningful activities in this area. However, while evidence about both forms of processing pre-dated the studies (as also indicated), it proved insufficient to shed light at the theoretical level. For one thing, prior research relating to explicit processing was primarily conducted with school-aged children and adults, while prior research relating to intuitive processing was focused upon the preschool age group. It is possible that what is true of preschoolers is also true of older groups, but to assume this a priori would be to presume that intuitive understanding is encapsulated from anything that happens subsequently at the explicit level. In other words, a theoretical perspective that is tantamount to the two-system approach would be presupposed when, as signalled already, the perspective is contentious. What is needed is research that examines explicit and intuitive processing in equivalent age groups and ideally the same samples, and at the time my studies were designed such research was scarce (but see Kaiser et al. 1992; Kim and Spelke 1999; Shanon 1976, for exceptions). In addition, prior research concerned with explicit processing has typically used more complex scenarios than prior research concerned with intuition. For instance, the studies mentioned earlier concerned with the predicted speeds of rolling objects usually manipulated some or all of propelling force, surface friction and direction of travel; propelling force alone was manipulated in the recognition tasks that Kotovsky and Baillargeon's (1994, 1998) used in this area. While exact comparability is clearly impossible, the demands made by tasks used to contrast explicit and intuitive processing should be as similar as possible.

With these considerations in mind, the four of my studies that attempted theoretical clarification were all conducted with 6- to 11-year-old children, with roughly equal numbers of children from three age groups (designated '6-year-olds', '8-year-olds' and '10-year-olds' in accordance with mean age levels). All children completed two tasks, a prediction task that required explicit processing and a recognition task that could be completed using intuitive processing alone. The tasks were presented 2 weeks apart and in every study half of the children at each age level completed the prediction task first and half completed the recognition task first. For their prediction task, the children viewed computer-simulated scenarios, which froze at critical points in object motion sequences. Through clicking on-screen buttons, the children had to indicate how the sequences would have continued. The recognition tasks used identical scenarios, except that instead of freezing they continued in either the natural fashion or a non-natural fashion. Here, the children had to click on-screen buttons to indicate whether or not the observed motion was correct. Critically then, recognition was assessed with reference to judgements and not measures of arousal. This is because Kim and Spelke's (1999) research had revealed methodological difficulties with assessing arousal by middle childhood. Reassuringly, their work with a late preschool group that was old enough to make judgements yet young enough to provide reliable arousal data produced results that were comparable across the two approaches.

Two of the four studies addressed horizontal motion (see Howe et al. 2014, for details). These studies employed billiards scenarios where a cue struck a white ball, which was positioned towards one end of a billiards table. The white ball then rolled and struck a red ball, which was positioned towards the centre. The scenarios varied over whether the white ball was struck hard or gently and on- or off-centre, and whether the motion was over glass or baize. Real cues, balls, baize surfaces and glass surfaces were available for handling. For the prediction task, scenario freezing occurred as the balls collided, and the children were asked to predict the subsequent direction (Study 1, $N=141$ children) or speed (Study 2, $N=132$) of each ball. In particular, for Study 1, the children predicted which of three pockets located at the other end of the table the red ball would roll into, and where the white ball would roll after striking the red ball. For Study 2, they were asked whether the red ball would be rolling faster, slower or with the same speed at two points, one near the ball's starting position and the other near its eventual pocket, and whether the white ball would be rolling faster, slower or with the same speed before or after colliding with the red ball. For the recognition task, the emphasis was upon judging whether post-collision direction (Study 1) or speed (Study 2) was correct when the scenarios continued in a natural fashion (e.g. the red ball rolled into the correct pocket, the white ball was slower after colliding with the red ball than before) or a non-natural fashion (e.g. the white ball bounced backwards after colliding, the red ball speeded up as it rolled across the table).

The other two studies (detailed in Howe et al. 2012) were concerned with object fall. Here, the scenarios depicted a hot air balloon, from which a ball was dropped. Three balls (which varied in mass and size) were used across the scenarios, and their real equivalents were available for handling. Sometimes the balloon was stationary at the point of dropping; sometimes it was moving. Sometimes the subsequent fall was through air and onto the ground; sometimes it was through air and then into and through water. Scenario freezing for the prediction task occurred at the point of dropping, with the children asked to predict the ball's subsequent direction (Study 3, $N=137$ children) or speed (Study 4, $N=133$). With Study 3, this involved presenting three sets of points (one set just below the balloon and the third near the landing place, i.e. under water in the air plus water scenarios), and asking the children to indicate which point in each set the ball would pass through. With Study 4, the children were asked whether speed would change or stay the same as the ball fell through air (air only scenarios) or as it fell through water compared with air (air plus water scenarios), and if they said speed would change whether it would get faster or slower. For the recognition task, the balls actually fell, sometimes naturally (e.g. in a forwards parabola when the balloon was moving, with accelerating speed through air) and sometimes non-naturally (e.g. vertically when the balloon was moving, faster in water than in air). The children were asked to judge whether the direction (Study 3) or speed (Study 2) was correct.

Unsurprisingly, the children were more accurate on the recognition task in all four studies than on the prediction task. Indeed, many errors on the recognition task were attributable to perceptibility difficulties rather than lack of understanding, e.g. when in Studies 1 and 2 the ball rolled very quickly after hard force along a glass surface. However, errors on the prediction task often indicated profound misconcep-

tions, and in many cases these misconceptions would be hard to reconcile with what earlier I called the single-system approach. Specifically, they could not be interpreted merely as partial versions of what was known intuitively, denuded due to enhanced task difficulty. For instance in Study 1, the white ball always struck the red ball centrally and without spin, meaning that it would invariably roll forward after impact in the same direction as the red ball. At all age levels, this pattern of motion was typically judged as correct on the recognition task, and alternatives rejected as incorrect. However, the modal response on the prediction task was that the white ball would bounce backwards after impact, i.e. travel in precisely the opposite direction. When Study 3's recognition task involved a moving balloon, the children acknowledged the naturalness of parabolic fall in the forwards pre-fall direction with a frequency at all ages that was well above chance. Acceptance of vertical fall as natural was the modal error. With the prediction task, the correct pattern was anticipated with only about 3 % of the scenarios that involved a moving balloon, and error profiles changed with age. Forward trajectories in the pre-fall direction (albeit non-parabolic ones) *decreased* with age from about 35 % of responses from 6-year-olds to about 13 % of responses from 10-year-olds. Backward trajectories in the opposite direction, which were scarcely ever accepted on the recognition task, *increased* with age from about 19 % of responses from 6-year-olds to about 57 % of responses from 10-year-olds. Finally at all age levels, the children in Study 4 consistently judged accelerating fall through air as correct and decelerating fall as incorrect when they viewed the two patterns during the recognition task. However, their responses on the prediction task were incorrect with 69 % of the scenarios, and when they erred the children almost always predicted that speed would decelerate. Constant speed was rarely suggested.

From these examples, it is clear that there must have been some differentiation between the background knowledge called upon when predicting and the background knowledge called upon during recognition. The implication is therefore that recognition does not only merely involve intuitive processing but also depends upon a body of intuitive knowledge. As noted, this does not simply support the two-system approach; it also, crucially for this volume, endorses Disciplinary Intuitions in the physical domain. However, further aspects of the data indicated that while intuitive knowledge and what might called explicit knowledge were distinguishable they must also have been linked to some extent. For one thing, there were further aspects of the results that, had the above examples not occurred, would have strongly suggested a single knowledge system. For instance, good performance at all ages on Study 2's recognition task means that the children must have adjusted intuitively to the varying effects of friction across the baize and glass surfaces. Furthermore, while the 6-year-olds took no account of friction on the prediction task, typically expecting the red ball to roll with constant speed regardless of surface, the older children frequently anticipated deceleration, especially with the rough baize surface. This shift from no use to partial use of concepts that are grasped intuitively is exactly what would be expected if the same knowledge was used in both recognition and prediction, but the additional processing required for prediction resulted in

some elements being overlooked. In other words, here the single-system approach appears to have been supported.

In addition, there were signs that on occasion explicit knowledge was accessed during the recognition task. For example, in contrast to the other studies where the natural and non-natural scenarios were associated with similar levels of accuracy, performance with the non-natural scenarios in Study 1's recognition task was markedly inferior (60 % correct) to performance with the natural scenarios (84 % correct). Moreover, while error profiles with the natural scenarios were suggestive of perceptibility difficulties along the lines outlined earlier, error profiles with the non-natural scenarios resembled those obtained with the prediction task. In particular, like the prediction task (and unlike the natural scenarios), performance with the non-natural scenarios was better when analyzing the red ball's motion than when analyzing the white ball's motion, and when analyzing the white ball's motion after off-centre propulsion compared with its motion after on-centre propulsion. The most plausible interpretation is that the children called up their explicit knowledge when judging the non-natural scenarios, perhaps because they felt intuitively that the scenarios were odd yet did not feel confident about their judgements. Therefore instead of responding instantly, they sometimes thought about what they had seen, just to be sure that what appeared odd was in fact odd. Taken as a whole then, the results from my studies suggest that neither the two-system approach nor the single-system approach can fully account for young children's understanding of object motion, implying the need, signalled earlier, for a compromise position that recognises separate but linked systems.

My studies have little to say about why physical knowledge employs a separate yet linked structure. However, adoption of a developmental perspective permits an informed guess. In terms of children's development, intuitive knowledge must pre-exist its explicit counterpart. Indeed, given the evidence described earlier for recognition accuracy before the first birthday and given the obvious survival value of such accuracy, innate underpinnings cannot be ruled out. Thus, remembering a point made earlier, namely that intuitive and explicit processing both start by relating presented events to existing representations, it is possible that when children first engage in explicit processing the representations they call upon are precisely the ones that pre-exist within their intuitive knowledge. Moreover, just as the single-system approach presumes, the inferences that explicit processing also requires once relevant representations have been accessed are influenced by whatever aspects of intuitive knowledge can be elevated to consciousness. This is the basis of links between the systems. However, elevated aspects will not dictate inferences (or at least they will not do this for long), and this is the basis of separation. In particular, a wide range of cognitive mechanisms (from automatic association to reflective analogising) guarantees that elevated aspects will become situated within networks of related concepts, and it is these networks that govern inferences (and so can be regarded as explicit knowledge). Some network concepts may derive from sociocultural experiences rather than intuition, and while such experiences may guide children's thinking towards scientific orthodoxy they may also support and even

exacerbate misconceptions. As noted, misconceptions about physical events continue into adulthood and therefore are likely to be replicated in adult–child dialogue. Media images may also contribute: films and the like often depict fall (e.g. of bombs) from inside moving carriers, and here the illusion is of backward descent in the opposite direction from the pre-fall motion. This may explain why, in Study 3, such trajectories were increasingly predicted with age.

Implications for Learning Environment Design

As noted earlier, evidence for links between sound intuitions about object motion and the explicit knowledge that underpins misconceptions provides grounds for anticipating that the former may be used to support growth in the latter. This is perhaps particularly the case when, as my studies suggest, children can access explicit knowledge during intuitive processing. If channels exist that allow access in that direction, it seems likely that they also permit access in the opposite direction. In particular when children engage in explicit processing, maybe they can be encouraged to consider their intuitive knowledge, with positive implications for knowledge and understanding. Reflecting on how this might be achieved, I began to contemplate a task format that synthesises the prediction and recognition elements of Studies 1–4, specifically a format where children would make predictions about object motion and then view scenarios that depict their predictions. Based on misconceptions, the predictions would often be incorrect and therefore the scenarios would be non-natural in the sense of Studies 1–4. However, from results obtained with those studies, children should recognise the non-naturalness, and this might trigger growth. I was aware that the history of science education is replete with failed attempts to use disconfirming evidence to address misconceptions (see, e.g. Duit et al. 2008; Harlen 1999), and the approach I was envisaging relied upon positive responses to disconfirmation. Indeed, neuroscience research demonstrates that disconfirming data often fail to activate the brain areas associated with learning (Fugelsang and Dunbar 2005). Nevertheless, Chinn and Brewer (1993) indicate that a key criterion for credible evidence is the provision of ‘data that the individual already believes’ (p. 25), and when the approach relies on the pre-existing intuitive knowledge upon which recognition is based, this criterion is clearly fulfilled.

In any event, the approach seemed worthy of further exploration, and this was the aim of Studies 5 and 6. For both studies, software was designed, which employed the scenarios used in Studies 1–4. The software began with prediction tasks identical to those used in the first four studies, i.e. scenarios that froze at critical points in object motion sequences and requests to indicate via on-screen buttons, how the sequences would have continued. Correct predictions triggered the message ‘Well done! You are correct’ inside a gold star, with an invitation to view the predicted motion. This was displayed using the appropriate natural scenario from Studies 1 to 4. Incorrect predictions triggered ‘Click on GO to see what you thought would happen’,

with clicking activating the appropriate non-natural scenario from the earlier studies. Once the scenario was complete, 'Did it look correct?' appeared on-screen, with NO or YES as response options. NO was expected to be the modal response, and when it occurred it triggered 'Yes, the motion of the ball was incorrect', together with an invitation to see what really happens. This was followed with 'What is the difference between the incorrect and correct motion?' and 'Why are they different?' The option was available of replaying the incorrect and/or correct motion as many times as necessary to answer the questions. YES was expected to be a rare response to 'Did it look correct?' but if it occurred, 'Sorry the answer is WRONG' would be triggered with an invitation to see what actually happens. For Study 5, the billiards scenarios from Studies 1 to 2 were used to address the direction and speed of horizontal motion, whereas for Study 6 the hot air balloon scenarios from Studies 3 to 4 were used to address the direction and speed of object fall. Although a full report of Study 5 is not currently available (but in preparation), Study 6 is detailed in Howe et al. (2013).

As a preliminary venture into a relatively uncharted domain, the research question underpinning the two studies was very simply whether the relevant software was beneficial for children's knowledge and understanding at the explicit level. Questions about how use of the software compared with other modes of teaching were left for future investigation, as were questions about whether, if benefits were detected, the intuitive processing engaged through recognition could be pinpointed as responsible. To address the target question, samples of 8- to 12-year-old children were recruited (Study 5, $N = 167$ children; Study 6, $N = 139$). Roughly one-third of each sample worked with the software individually, with a researcher on hand to scaffold scenario interpretation and guide task procedures upon request (Single Group). A further third worked with a classmate, with the adult offering procedural guidance upon request but otherwise being deliberately passive (Pair Group). While full exploration of contextual factors was beyond the studies' scope, it was recognised that learning environments are not specifiable purely with reference to the task undertaken. Therefore, an attempt was made to mimic two contexts, which not only occur frequently during computer-based sessions in classrooms (Crook 1994) but are also known to be associated with markedly different patterns of discourse (Anderson et al. 1993). The final third of the samples did not work with the software (Control Group). Assignment to groups was random.

Prior to assignment to the Single, Pair and Control Groups, the full sample in each study was pre-tested to assess initial understanding, and a few weeks after work with software was completed the full sample was post-tested to assess knowledge gain. The pre- and post-test were identical. For each study, a researcher displayed 16 successive scenarios to whole classes using PowerPoint slides. The scenarios for Study 5 covered the collision of a moving ball with a stationary ball in the contexts of billiards, bowls and marbles; the scenarios for Study 6 covered fall from hot air balloons, helicopters and trains on high bridges. The scenarios varied in a fashion that allowed all of the key contrasts that had emerged from Studies 1 to 4 to be represented, e.g. rolling over rough or smooth surfaces, falling from moving

or stationary carriers. Using answer booklets that replicated the slides, the children predicted outcomes, i.e. direction or speed post-collision or during fall. With eight scenarios in each test, outcomes also had to be explained through ticking whichever causal factors were applicable from listed options. Some options were appropriate, e.g. 'A force pulling the ball downwards' in Study 6, and some were inappropriate, e.g. 'The air pulling the ball downwards'. Explanation is widely required in science education, and like prediction, it also involves relating to representations, considering relations and drawing inferences, and therefore using explicit knowledge.

Each child could be assigned 'prediction scores' (total number of correct predictions) for their pre- and post-test responses, 'correct explanation scores' (total number of ticks against actual determinants of outcome), and 'incorrect explanation scores' (total number of ticks against irrelevant factors). Pre- to post-test gain was indicated to the extent that the first two scores increased and the final score decreased. At pre-test, the children in the Single, Pair and Control Groups in both studies obtained equivalent mean scores on all three measures. At post-test in Study 5, the children in the Single and Pair Groups obtained significantly higher mean prediction scores and mean correct explanation scores than the children in the Control Group. The differences were especially marked for the Single Group, where there was also a sharp decline in incorrect explanation scores. At post-test in Study 6, the children in the Single and Pair Groups obtained significantly higher mean prediction scores than the children in the Control Group, with the differences this time particularly marked in the Pair Group. In Study 6, there were no differences between the three groups at post-test over correct or incorrect explanation scores. In both studies then, working with the software had positive implications for understanding at the explicit level, although the nature of the implications differed. The substantially higher mean prediction scores obtained in Study 5 compared with Study 6 suggest one possible interpretation of the differences. Specifically, the greater understanding of horizontal motion that this implies may have created space in Study 5 to process at the explanatory level. Moreover with space, there may have been greater receptivity to adult scaffolding, which would have included guidance at the explanatory level, accounting perhaps for why the Single Group (who received scaffolding) was more successful than the Pair Group in Study 5. It is harder to understanding why in Study 6 the Pair Group was actually more successful with predictions than the Single Group. However, it may be relevant that the paired children talked at length about their predictions as they worked with the software. At the very least, this will have slowed them down and made them think as they inputted responses via the computer.

Whatever the interpretation of why the studies differed, the fact that the Single vs. Pair contrast had consequences for outcome in both studies signifies a strong sociocultural dimension to how the software was perceived. This is unsurprising given conclusions drawn in the previous section, for there it was argued that sociocultural experiences of dialogue and media imagery most likely contribute to the partial severance of explicit knowledge from its intuitive foundations. The implication

is that when drawing conclusions for learning environment design, it is critical not to focus on the software alone. Resonating with many other chapters in this volume, the learning environment should be construed as the software and the sociocultural context in which it is located. Nevertheless, while many issues remain to be resolved (around optimising the software–context relationship and indeed, as signalled earlier, around the software itself), the approach exemplified in Studies 5 and 6 does appear to hold promise. The software provides a relatively straightforward illustration of how prediction and recognition can be combined in a single task, and by implication how intuitive processing can be harnessed in support of explicit. The results indicate that explicit knowledge benefitted through work with the software. In sum then, while Studies 5 and 6 cannot be regarded as conclusive, they are hopefully sufficient to stimulate further research.

Conclusion

While my six studies were not designed with Disciplinary Intuitions in mind, they can be interpreted as supporting both the theory and its educational relevance. In demonstrating through Studies 1–4 that recognising the naturalness or non-naturalness of object motion calls upon a partially encapsulated form of knowledge, the Disciplinary Intuitions is given credence. In showing through Studies 5 and 6 that recognition can be meaningfully employed as feedback on explicit forms of engagement (and explicit knowledge subsequently progresses), a *prima facie* case is made for educational relevance. Nevertheless, the support that the studies provide is limited to one specific topic area, object motion, where the adjustments that must be made to ensure accurate recognition (to the effects of friction, gravity, inertia, etc.) map very closely upon key concepts within formal physics. In other words, formal physics provides a reasonable model of intuitive understanding, just as linguistic theory provides reasonable models of native speaker competence. With other aspects of the physical world, for instance the form and function of the solar system, intuitive knowledge is scarcely plausible, let alone likely to be related to formal representations. With topics such as physical geography, candidates for intuitive underpinnings can be identified, e.g. the knowledge of spatial relations that infants display. However, the mappings seem much less direct than the ones considered here.

The implication is therefore that any cross-disciplinary representations of the relations between Disciplinary Intuitions and educational practice are likely to be expressed at a very high level of (possibly unhelpful) abstraction, and seen in that light the present volume's strategy of addressing intuitive knowledge on a case-by-case basis seems very prudent. In that context, my analysis of object motion can hopefully play a constructive and complementary role.

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