Lecture Notes in Educational Technology

Ronghuai Huang
Kinshuk
Nian-Shing Chen *Editors*

The New Development of Technology Enhanced Learning

Concept, Research and Best Practices

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Lecture Notes in Educational Technology

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Editors

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ISSN 2196-4963 ISSN 2196-4971 (electronic)
ISBN 978-3-642-38290-1 ISBN 978-3-642-38291-8 (eBook)
DOI 10.1007/978-3-642-38291-8
Springer Heidelberg New York Dordrecht London

Library of Congress Control Number: 2014942925

Printed on acid-free paper

Springer is part of Springer Science+Business Media (www.springer.com)

Foreword

From Technology Enhanced Learning to Technology Enhanced Learner

With the development of the World Wide Web in the mid-1990s, the possibility of technology-enhanced learning (TEL) as a global infrastructure became a reality. The first learning management systems soon followed, and within a few years organizations like IMS had already begun to standardize things like learning object metadata and learning design.

It is perhaps not surprising that the first forays into TEL looked a lot like traditional classroom-based education. That is what the SAMR (Substitution Augmentation Modification Redefinition) model suggests would happen.[1] And, not surprisingly, from these simple beginnings TEL began to be augmented, modified and redefined. This volume tells that story.

Consider, for example, the models we used to describe learning. Whether it be the experiential learning of John Dewey or the social construction of Lev Vygotsky, we read a story concerning the organization and presentation of content in such a way as to enable the learner to absorb and retain a body of knowledge, whether through watching and listening or by experiencing and constructing.

But technology changes not only our understanding of learning, but even our understanding of the learners themselves. The reader will be familiar with Tapscott's 'digital natives'[2] and therefore with the idea that the 'net generation' reads and understands and *thinks* differently from previous generations. But what might not

[1]Puentedura, R. R. (2003). A matrix model for designing and assessing network-enhanced courses. http://hippasus.com/resources/matrixmodel/puentedura_model.pdf. Retrieved April 12, 2011: 2013.

[2]Tapscott, D. (1998). Growing up digital: The rise of the net generation. New York: McGraw-Hill.

be more widely understood is that the globally pervasive nature of technology may be having a similar effect worldwide, as suggested by Huang and Yang.[3]

The concept of technology *enhanced* learning suggests that we are retaining the same old picture of learning and simply adding to it. But this picture changes when we think of the technology enhanced *learner*. Take, for example, what happens to the ages-old practice of storytelling when it is put into the hands of a child equipped with robots and projectors. A pilot student of students in Japan suggests that their motivation is increased and that they are drawn into discussions that deepen their understanding of the subject.[4] It is not that they are simply learning more, they are learning *differently*. Moreover, the technology enhanced learner will have more and greater capacities than his or her counterpart in the pre-technology era. This especially applies to disabled or disadvantaged learners.[5]

As students change and adapt to the new technology, they begin to learn differently and to learn new things. They begin, for example, to speak and communicate with each other in different ways, even using their own language. I have suggested, for example, that digitally literate students 'speak in LOLcats', that is, they use internet memes as shorthand to communicate ideas with each other.[6] Marc Prensky urges not only to use their tools, but to speak their language.[7]

Perhaps we agree with the sceptics[8] who question whether we can associate generational preferences with new technologies. It can nonetheless be argued that TEL introduces new *ways* of learning, and even of communicating. What can we say, for example, of gesture based interfaces, except that they take us from spoken and written word, the traditional media of learning, to a form of wordless mime. Technologies like the Wii and Kinnect have *embodied* digital learning (something even a few short years ago Dreyfus argued[9] was not possible). But it is not just an enhancement of traditional learning; indeed, we read in this volume that while gesture-based interfaces have the capacity to enhance body-related experience, they do not reduce cognitive load or enhance more traditional learning.[10]

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[3]Huang, R., & Yang, J. (2014). The framework and method for understanding the new generation of learners. Dordercht: Springer.

[4]Sugimoto, M. (2014). Design of technology-enhanced learning environments that connect classrooms to the real world. Dordrecht: Springer.

[5]Jemni, M, Baabidi, M., & Jemni ben Ayed, L. (2014). Accessible e-learning for studemnts with disabilities: From design to implementation. Dordrecht: Springer.

[6]Dowes, S. (2009). Speaking in Lolcats: What literacy means in the digital era. Slideshare. http://www.slideshare.net/Downes/open-education-projects-and-potential

[7]Prensky, M. (2004). Use their tools! Speak their language! http://www.marcprensky.com/writing/Prensky-Use_Their_Tools_Speak_Their_Language.pdf

[8]Smith, E. E. (2012). The digital native debate in higher education: a comparative analysis of recent literature. Canadian Journal of Learning and Technology 38(3). http://www.cjlt.ca/index.php/cjlt/article/download/649/347

[9]Dreyfus, H. L. (2001). On the internet. London: Routledge.

[10]Nian-Shing Chen, & Wei-Chieh Fang. (2014). Gesture-based technologies for enhanced learning. Dordercht: Springer.

My own introduction to TEL many years ago was in the form of online role playing games in what were then called ‘multi-user dungeons’ (MUDs). A person trying to solve a quest is engaged in a different sort of activity than a person trying to remember some process, facts or figures. The rise of gaming in learning, facilitated to a degree not previously possible with TEL, challenges our existing models of learning design and challenges our understanding of the learning process itself. Perhaps we should think of learning, not in terms of content, but in terms of system design and models.[11] Perhaps learning activity generation is more like game design.[12]

This again takes us not only into a new type of learning but also of an understanding of a new type of learner. James Paul Gee talks about this as the development of the learner’s *social identity*.[13] In this volume the idea of the development of collaboration skills through game-based learning is reinforced.[14] We now begin to think of the digital learner as a person who thinks in models, who defines his or her identity working with others in a problem-centered environment and one who is a very different sort of person than characterized traditional learning.

And, in essence, that is what this volume is telling us. Though its focus is on the current status of technology enhanced learning, the story it tells is of a learner, capable and even eager to use new technologies, accessing and organizing knowledge and learning in new ways, with new media, and as a result, thinking and seeing the world differently, and indeed, becoming a different kind of person. From technology enhanced learning we derive the technology enhanced learner, and as this volume makes clear, we are only beginning to understand the potential.

Moncton, New Brunswick, Canada Stephen Downes

[11]Martens, A. (2014). System design and modeling of TEL. Dordercht: Springer.

[12]Lu, C., Chang, M., Kinshuk, Huang, E., & Ching-Wen Chen (2014). Context-aware mobile role playing game for learning. Dordercht: Springer.

[13]Gee, J. P. (2008). Learning and games. The ecology of games: Connecting youth, games, and learning. In: K. Salen (Ed.), *The John D. and Catherine T. MacArthur foundation series on digital media and learning* (pp. 21–40). Cambridge, MA: The MIT Press. http://ase.tufts.edu/DevTech/courses/readings/Gee_Learning_and_Games_2008.pdf

[14]Caruso, V., Mørch, A. I., Thomassen, I., Hartley, M., Ludlow, B. (2014). Practicing collaboration skills through role-play activities in a 3D virtual world.

Preface

During the past years, the increased interest for applying digital technologies aiming to improve learning and teaching has led to the evolution of the research discipline of Technology Enhanced Learning. Typically, Technology Enhanced Learning refers to a transformative movement in learning and teaching that exploits technological advances for offering learning experiences.

Several different types of computer-based systems have been developed under the term TEL, for teaching, learning and training. Starting with Hyperbooks and Intelligent Tutoring Systems (influenced by cognitive psychology), going to other adaptive systems, embracing single-user and multi-user systems, and, in recent years, using mobile technologies, a plethora of systems have emerged. Surprisingly, many of these systems remain in research realm and have not made their way to commercialization. Still, the emergence of this whole area leads to the discussion regarding what constitutes an enhancement of the student learning experience and how can technology contribute to enhancing learning?

The sharing of concept and research and best practices in this book intend to probe these questions from different perspectives, and hope to help researchers and practitioners in identifying effective uses of technology to support learning.

The book is structured into three thematic parts. Part I deals with the new concept development of technology enhanced learning and sets the stage for the other parts of the book. Part II provides a glimpse of emerging technologies supporting technology enhanced learning to facilitate effective learning. Part III introduces the best practices in technology enhanced learning; as a result, readers will find the solutions of using technologies in education and the cases of how to integrate these technologies into learning.

Part I: The New Development of Concept in TEL

The first part of the book consists of five chapters.

Ronghuai Huang and Junfeng Yang investigate the framework and method for understanding the new generation of learners, and subsequently analyze, through a large scale survey and interview, the gap in the ways of learning students preferred and K-12 classes provide.

Alke Martens discusses how different levels of system design can be supported by models which work independent of the programming language, can be re-used for the development of some different system types, and can be used as boundary objects for interdisciplinary communication.

Masanori Sugimoto describes several technology-enhanced learning environments to connect classrooms to the real world and evaluates them in a school setting.

Mohamed Jemni, Mohsen Laabidi and Leila Jemni Ben Ayed present their work towards developing an accessible e-learning system for students with disabilities starting from the design to the implementation.

Panagiotis Zervas, Alexandros Kalamatianos and Demetrios G Sampson focus on metadata interoperability of different learning object repositories that have been developed by institutions, communities and consortiums across Europe, and present the results of a systematic analysis of metadata APs used in 19 European learning object repositories.

Part II: The Emerging Technologies Supporting TEL

The second part of the book consists of four chapters.

Nian-Shing Chen and Wei-Chieh Fang explore the relationship between embodied cognition theories and technologies by presenting: (1) the ways of interacting with computers using gesture-based computing, (2) the overview of the theories and findings from psychology and education, and (3) potential research frameworks for future studies.

Guang Chen, Chaohua Gong, Wei Cheng, Xiaoxia Zheng and Ronghuai Huang identify various potential issues in utilizing e-textbook in classes and examine the change from paper textbook class in technology rich classrooms to electronic textbook class in such classrooms.

Chris Lu, Maiga Chang, Kinshuk, Echo Huang, and Ching-Wen Chen reveal the design of personalized context-aware mobile learning activity generation approach and transition story generation approach, and describe an educational game designed using these approaches. They also describe two pilot studies that were conducted to assess the game.

Arif Altun and Galip Kaya report on the development and evaluation of an ontology based navigation and retrieval tool for educational purposes using learning objects.

Part III: The Best Practice of TEL

The third part of the book consists of four chapters.

Valentina Caruso, Anders I. Mørch, Ingvill Thomassen and Melissa Hartley report on the preliminary findings of a case study using the 3D virtual world Second Life in a pre-service teacher distance education program. They argue that synchronous online learning environments present great opportunities for combining traditional pedagogical approaches and virtual world pedagogy in order to overcome barriers between educational theory and pedagogical practice in teacher education programs.

Marcus D. Bloice, Klaus-Martin Simonic and Andreas Holzinger report on the development of an iPad-based Virtual Patient simulation system that uses annotated electronic patient data and health records for the creation of cases to enable students to learn critical decision-making skills.

Donna Russell, Steve Genstler and Lea Wood provide an overview of case study research consisting of three programs to identify the variances in the effectiveness of the integration of mobile technologies.

Kannan M. Moudgalya describes an information technology literacy promotion drive in India using Spoken Tutorials, which are screencast videos of 10 min duration. Feedback received from self-learning workshops, feedback from 25,000 students, and testimonials vouch for the usefulness of the Spoken Tutorial methodology.

In conclusion, this compilation should benefit learners, educators, scholars and trainers by providing them an insight of the new developments of concept, emerging technologies and best practices in technology enhanced learning.

We would like to express our gratitude to all those who provided support, talked things over, read, wrote, offered comments, allowed us to quote their remarks, and assisted in the editing, proofreading and design.

Beijing, China — Ronghuai Huang
Alberta, Canada — Kinshuk
Kaohsiung, Taiwan — Nian-Shing Chen

Contents

Part I
The New Development of Concept in TEL

Chapter 1
The Framework and Method for Understanding the New Generation of Learners

Ronghuai Huang and Junfeng Yang

Abstract Social informatization has brought great change to lifestyles, which is mainly reflected in communication, commerce, and leisure; at the same time, their perspectives on capability, knowledge, and learning have changed. A large number of researchers have proposed that students who have grown up with digital technology are quite different from the previous generation, while other researchers believe that changes amongst students are already well understood and the educational implications are already known. This chapter first reviews the terms, debates, and research for the new generation of learners, and then proposes a framework for understanding the new generation of learners. At the end of the chapter, we analyze the gap between learning methods preferred by students and that provided by K-12 classes using the framework of a large-scale survey and interview.

Keywords Digital native • New generation of learner • Framework • Debate

1.1 New Generation of Learners: Terms, Debates, and Research

In the book *Generations*, Howe and Strauss (1991) first coined the term 'Millennial Generation' (defined as those born between 1982 and 2000) as successors to, but not wanting to be associated with, 'Generation X' (born between 1961 and 1981). The basic characteristics of Millennials are that they are special, sheltered, confident, team-oriented, achieving, pressured, and conventional.

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R. Huang et al. (eds.), *The New Development of Technology Enhanced Learning: Concept, Research and Best Practices*, Lecture Notes in Educational Technology,
DOI 10.1007/978-3-642-38291-8_1,

Marc Prensky (2001) described this generation as 'digital natives' because he found them to be 'native speakers' of the digital language of computers and the Internet. Digital natives are accustomed to the twitch-speed, multitasking, random-access, graphics-first, active, connected, fun, fantasy, quick-payoff world of video games, MTV, and the Internet.

In the book *Growing Up Digital: The Rise of the Net Generation*, Tapscott (1998) argued that the generation of children who grew up with the new medium was defined by their relationship with digital technology and described them as the "net generation" (N-generation) or the "N-Geners". Brown (2005) identified the nine learning characteristics of the net generation as follows: group activity, goal and achievement orientation, multitasking, trial and error, heavy reliance on network access, pragmatic and inductive, ethnically diverse, visual, and interactive. In the article *Teaching Strategies for the Net Generation*, Berk (2009) identified 20 characteristics of N-Geners: technology savvy, relies on search engines for information, interested in multi-media, creates internet content, operates at a fast speed, learns by inductive discovery, learns by trial and error, multitasks on everything, shortened attention span, communicates visually, craves social face-to-face interaction, emotionally open, embraces diversity and multiculturalism, prefers teamwork and collaboration, strives for lifestyle fit, feels pressure to succeed, constantly seeks feedback, thrives on instant gratification, responds quickly and expects quick responses in return, and prefers typing to handwriting.

These four terms essentially expressed one idea: that current students were different because they had grown up with digital technology. However, researchers like Bennett et al. (2008), Selwyn (2009), Jones and Ramanau (2010), Romero et al. (2010), and Bullen et al. (2001) argued that, while digital technologies were associated with significant changes in the lives of young people, there was no evidence of a serious break between young people and the rest of society. Jones and Hosein (2010) argued that there was not a single 'net generation' with common characteristics, and age seemed to be only one of several interrelated factors, rather than the sole factor.

Whether students who had grown up with technology represented a new generation was debated by two groups of researchers. Nevertheless, both sides thought that, although students who had grown up with technology could not represent a generation, they did have some unique characteristics associated with technology.

Research on the new generation of students has mainly been based on literature review, but evidence-based research has been increasing in recent years. Research on the accuracy of descriptions reflecting the actual use of digital technology and information by young people showed that their engagement with digital technologies was varied and often unspectacular – in stark contrast to popular portrayals of the digital native by Selwyn (2009). A survey by Jones et al. (2010) of first-year undergraduates studying a range of pure and applied subjects showed a complex picture, with the sample population appearing to be a collection of minorities. Brown and Czerniewicz (2010) conducted a research project on access to and use of information and communication technologies (ICTs) by South African higher education students and showed that age was not a determining factor in their digital lives; rather, familiarity and experience using ICTs was more relevant.

Given the growing body of evidence that simultaneously refutes the simple notion of the 'digital native' and highlights the complexities of young people's technology experiences, it will continue to be important to measure access and activity through large-scale surveys (Bennett and Maton 2010). Bennett and Maton (2010) suggested some ways of conceptualizing the research issues of the new generation of students, drawing on theories from the sociology of education and knowledge, and they advocate more in-depth research on current students. As researchers have highlighted, large-scale surveys will give us a deeper understanding of current students and provide evidence to understand the complex relationships between teacher, learner, and technology. A general framework to describe a full picture of today's student's learning, living, and working environment, from both an online and an offline perspective, would be of great help for a large-scale survey, which could provide reference or guidance for survey and research. The general framework could also act as a rubric for comparing students' character differences between different countries or districts, which will be helpful when analyzing the characteristics of students by aggregating and mining large amounts of data.

1.2 The Framework for Understanding the Cyber Lifestyle of Students

Computer use has grown exponentially since the invention of the microcomputer three decades ago; as of mid-2010, almost one-third of the world's population uses the Internet (OECD 2011). Digital technologies have changed the environment in which students live; those changes have had an impact on how students learn. To fully understand learner characteristics, we should look not only at learning that takes place in school but also at learning that takes place out of school. The reviewed literature on digital natives indicated that the debate lay in the research perspective: one section concerned learner characteristics from the perspective of individual behavior and preference (Prensky 2001; Crook 2012; Comparing 2013); however, another section concerned the overall situation by investigating students as distributed in society as a whole (Bennett et al. 2008; Jones et al. 2010; Li and Ranieri 2010). While school is the most important learning environment for students, it is important to look at their learning characteristics in school. Therefore, we propose a three-layer framework for understanding today's students, comprising a student layer, a school layer, and a society layer, and concerning the characteristics of the individual learner, learning in school and at home, and the overall technological and social environment separately.

We propose Fig. 1.1 to emphasize the diversity of students, and we call on researchers and practitioners to pay attention to and consider the diversity of and differences in students. Diversity not only reflects the individual characteristics of students (such as self-directed efficiency, learning preference, Netizen age, and technology access), but also depends on education from school and home. Factors such as home–school connection, curriculum, teaching model, parental

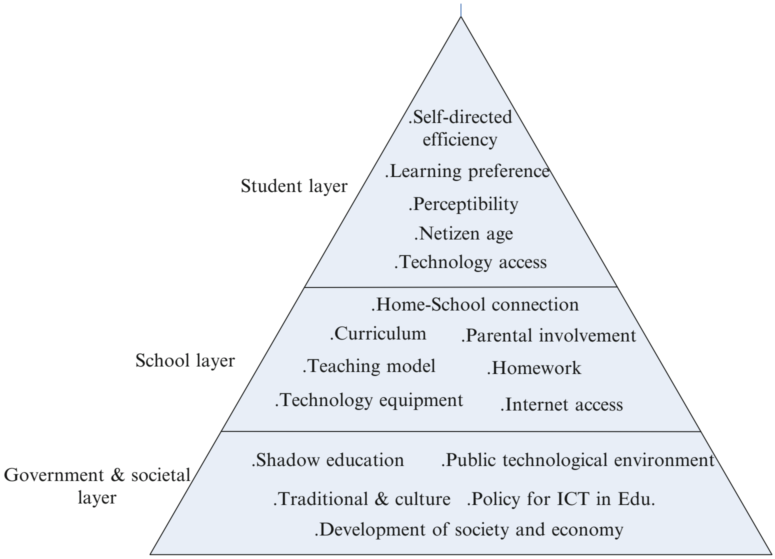

Fig. 1.1 Learning circumstances model for K-12 students

involvement, homework, technology equipment, and Internet access should be considered; the diversity may also be influenced by the entire social environment, such as shadow education, public technological environment, tradition and culture, policies regarding ICT in education, and social and economic development.

1. Exactly what differences exist between digital natives and earlier-generation students in their learning needs and characteristics?

Social and economic development requires that educational systems equip young people with new skills and competencies that allow them to benefit from the emerging new forms of socialization and to contribute actively to economic development under a system in which the main asset is knowledge (OECD 2009). A growing number of business leaders, politicians, and educators are united around the idea that students need 'twenty-first century skills' to be successful today. Information, media, and technology skills, learning and innovation skills, life and career skills are all included in the 'Partnership for 21st Century Skills' framework, which has been widely adopted. Information literacy refers to the ability to access, evaluate, use, and manage information; media literacy refers to the ability to analyze media and create media products; and technology literacy refers to the ability to use technology as a tool to research, organize, evaluate, and communicate information in an ethical and legal way (Partnership 21st Century Skills 2006).

Some commentators have claimed that digital natives differ from the earlier generation in the way they are using digital tools and twenty-first century skills (Prensky 2004). On the other hand, other researchers argue that digital natives are not necessarily knowledgeable about and skilful in information, media, and technology literacy, especially in learning situations (Bennett et al. 2008; Bennett and Maton 2010; Jones 2010; Selwyn 2009). However, Gu et al. (2013) indicated that differences between teachers and students with regard to technology lie in how they utilize technology and how important they perceive it to be. They also pointed out that their study may help us better understand new millennium learners and provide them with appropriate classroom technology products. Information, media, and technology literacy has always been considered in studies on the learning characteristics of digital natives; however, (Kolikant 2010) concluded that low self-efficacy might mean students are less likely to apply themselves to learning even though they are proficient at using technology. In order to fully understand the digital native, self-regulated learning ability, perceptibility, and learning preference should also be considered. Brown and Czerniewicz (2010) found that instead of a new generation growing up to replace an older analog generation, there was a deepening digital divide characterized not by age but by access and opportunity. Therefore, it makes sense to understand the diverse characteristics of learners who have different technology access in a region, which will contribute to teachers' instructional design and course development.

2. What functions should school education and home education play?

The two most influential contexts in which young children's learning and development occur are home and school (Galindo and Sheldon 2012). Epstein (2001) argues that the home and school constitute "overlapping spheres of influence" on children's development and academic achievement, and that the degree to which educators and family members maintain positive relationships with each other helps determine children's academic success. Thus, school and family are the two most important factors influencing student learning, and the functions and relationships of the two aspects should be considered to understand student's characteristics. Studies have also shown that family involvement at school can have a positive influence on young children's education and cognitive development (Galindo and Sheldon 2012). Schools should develop and implement policies that promote parental engagement, so there is effective communication and sharing between family and school, and parents can become empowered and enabled to advocate for their child throughout life (Capitão et al. 2012). With the development of educational informatization, the flipped classroom became a popular teaching model and enhanced relationships between school and family education. Therefore, it is important to identify the new roles, responsibilities, and connections between home and school in this internet age, which will contribute to the understanding of digital learners.

While the formal learning that occurs within the organized and structured context of school is the basic form of learning today, non-formal learning (which consists of learning embedded in planned activities that are not explicitly designated as learning) and informal learning (defined as learning resulting from daily life activities related to work, family, or leisure) have become increasingly important (Colardyn and Bjornavold 2004). When striving to understand the learner, the overall learning scenario should be considered, not just school-based learning activities.

3. In what environments do students live nowadays: the physical world or the virtual world?

Technology is arguably the lynchpin of our modern society. It is hard to conceive of many aspects of our lives that do not rely on technology in general and computers in particular (Cooper 2006). With the use of digital technology, a digital divide has emerged (referring to an economic inequality between groups, broadly construed in terms of access to, use of, or knowledge of ICT) (U.S. Department of Commerce and National Telecommunications and Information Administration NTIA 1995). Research has suggested that income and education are important determinants of computer ownership and Internet use, and thus may contribute to digital divides (Chinn and Fairlie 2006). Goldfarb and Prince (2008) explain why differences in Internet use matter, contributing to inclusion and exclusion, and it is believed that high-income and educated families generally adopted more Internet usage than lower-income and less educated families (Goldfarb and Prince 2008). Today, learning is no longer confined to the classroom; learning happens in the home, at the museum, in cafeterias, in sports, in travel, etc., where students have communication with others and society (Schugurensky 2000). Learning happens not only in the physical world, but also in the virtual world, in places such as digital museums, social networks, online videos, online gaming, etc., where students communicate with computers and systems. Students with more Internet usage may be more immersed in the virtual world. To understand today's learner, we should consider the activities students often undertake in the virtual world and the differences between students who can easily access the Internet and those who cannot. Digital natives have grown up with digital technology. It is generally believed that students who have used digital technology for longer will be more proficient in using it; however, digital divides have resulted in students occupying different physical and virtual environments. Therefore, investigating the environment in which students live nowadays could be helpful in understanding the characteristics of students.

Considering the above three aspects, we proposed a framework for understanding the cyber lifestyle of students, as shown in Fig. 1.1. Self-planning, self-management, self-evaluation, information/technology/media literacy, perceptibility, and preference are key aspects for understanding the characteristics of learners. Learner characteristics are speculated upon with the background of both school and family, and communications between school and home are also included in this framework. Other activities outside school and family could be viewed from both the physical and the virtual world. The frequency with which students visit museums, theaters, Internet cafés, and libraries, as well as undertaking activities such as outside sports, outdoor activities, travel, and attend shadow education could reflect the balance of leisure and study in the physical world. Visits to digital museums, and use of online videos, augmented reality applications, and e-books, as well as the activities of online learning, surfing, social networking, and gaming could reflect their cyber leisure and study.

1.3 The Survey of Students' Cyber Lifestyle in Beijing

We conducted a large-scale survey in Beijing, the political, educational, and cultural center of China. Education in Beijing is ranked as number 1 in China, and students can generally easily access technology. However, a digital divide still exists in Beijing, and huge differences exist in technology access between rural and urban areas. The primary teaching method in mainland China involves the teacher delivering and the student memorizing, with the objective of passing examinations. As a result, shadow education is very common in mainland China.

Based on an analysis of the situation in Beijing, we identified the following issues for this research by selecting elements from the framework for understanding the cyber lifestyle of students.

1. Learning approach preferred by students
2. Survey of student's media literacy
3. Survey of students using Internet excessively
4. Communication between home and school
5. Survey on student's Internet leisure

Stratified sampling was used in this survey. First, we selected eight districts, covering the urban, rural, and sierra areas from 13 districts in Beijing; then we selected schools covering leading schools and normal schools in each district; then students from K-3, K-5, K-8, and K-11 were selected as participants. Approximately 28,300 students in Beijing from four different grades, including primary schools and middle schools, took part in the survey, and we collected a final total of 28,251 questionnaires. Responses reflected the following age groups: in primary school, grade 3 students aged approximately 9 years (25.1 %); grade 5 students aged approximately 11 years (28.9 %); in junior middle school, grade 2 students aged approximately 14 years (28.5 %); in senior middle school, grade 2 students aged approximately 17 years (17.5 %). Huang et al. (2012) published the results of the survey in the CLoS 2012 Blue Paper.

1. Learning approach preferred by students
   (a) The learning preferences of elementary, junior, and high school students differed significantly: elementary school students preferred direct instruction, junior school students preferred group discussion, and the preferences of high school students were more diverse.
   (b) With each rise in grade level, the Internet gradually became the main source of students' knowledge out of school; however, guidance and help in using the Internet is still needed.
   (c) The frequency with which students prepare before class gradually reduced with each rise in grade (K-3 students 46.8 %; K-11 students 9 %).
   (d) More than 30 % of students indicated that teachers had arranged for them to use the network to complete their homework.

(e) A higher percentage of students participated in shadow education, which could raise their academic achievement and foster capacity development, but also brought more pressure to their physical and mental health.

2. Survey of student's media literacy

The Internet has a significant influence on the living and learning of primary and middle school students in Beijing; however, 17.1 % of students have still never accessed the Internet. Students have a strong desire to improve their Internet literacy, but media literacy education in schools is relatively lacking.

(a) Both ownership and usage rates of the Internet are high in Beijing, but the 'digital divide' still exists.
(b) There is a big difference in Internet use inside and outside school, which could be termed the 'new digital divide'.
(c) Personalization and entertainment are the two main features in students using the Internet, and mobile Internet usage is an emerging trend.
(d) Students have a strong sense of preparedness and ability to question Internet information, but the depth of ability to analyze intentions behind information, and therefore critical thinking skills around information need to be improved.
(e) Students are curious about items on the Internet, but network awareness, involvement, and expression are poor.
(f) Students' sense of self-protection needs to improve, and language violence, account theft, dissemination of false information, and other harmful behaviors exist when students use the Internet.
(g) Parents take a conservative attitude to children's use of the Internet, and containment has become the primary method for parents to manage their children's use of the Internet.
(h) Media literacy education in schools is inadequate and should be improved.

3. Survey on student's Internet addiction

(a) 88 % of students are able to use the Internet moderately, 1.4 % of students use the Internet excessively, and 10.6 % of students tend to use the Internet excessively.
(b) Students who use the Internet excessively and those who tend to use the Internet excessively increase with each rise in grade.
(c) Students who use the Internet excessively often have a long netizen age, long daily time on the Internet, a low percentage of home Internet access, and a higher percentage of Internet café and mobile Internet access.
(d) Students who use the Internet excessively have more conflicts with their parents, and parental help for their learning is relatively less.

4. Communication between home and school

(a) The aim of communication between home and school mainly lies in solving students' various learning problems, while little attention has been paid to mental and physical health.

(b) The methods of communication between home and school are diverse, and phones and networks have been used in a wide range.
(c) 43.3 % of students indicated that they knew of the parents' committee, but they thought the organization was loose, which resulted in less participation in school affairs.

5. Survey on student's use of the Internet for non-learning activities

(a) Students who completed school learning tasks (including learning in class and homework after class) mainly independently arranged their free time (planning and deciding what to do), but a small number of students (4.4 %) exist for whom it is arranged by parents.
(b) More than half of the student's parents were concerned about activities in which their children are involved in their free time, and parents are willing to accompany their children to activities their children would like to do.
(c) Nearly half of the students' favorite things to do is surfing online or watching TV at home in weekend or on holidays.
(d) 81.1 % of students are quite satisfied with the available free time and the activities they undertake in that time.

1.4 Investigation of Students' Preferred Learning Approach

The survey on the preferred learning approach of students is introduced in this section, and the structure of the questionnaire is shown in Fig. 1.2. All elements were selected from the framework for understanding the cyber lifestyle of students. Learning preference, information/technology/media literacy, and self-regulated learning were selected from the student character layer, and shadow education was also included for its direct influence on learning preference.

A learning scenario is a comprehensive description of one or a series of learning events or learning activities, which includes four elements: learning time, learning place, learning peers, and learning activities (Huang et al. 2013). The learning preference was designed based on the learning scenario. As students were reported to have grown up with digital technology and to be proficient in using technology, the survey of information/technology/media literacy would provide insights on their use of technology for learning. Self-planning, self-management, and self-evaluation were surveyed to understand the self-regulating ability of students. As shadow education was very common, understanding the frequency, subjects, strength, and weaknesses would help in understanding the change in student's learning approach (Fig. 1.3).

The survey of learning preferences of students indicated the following results.

1. The preferred method of learning in the classroom was listening to a lecture (47.3 %), collaborative discussion in groups (26.1 %), self-learning (8.2 %), and one-on-one tutoring (18.4 %). However, students in primary, junior, and senior

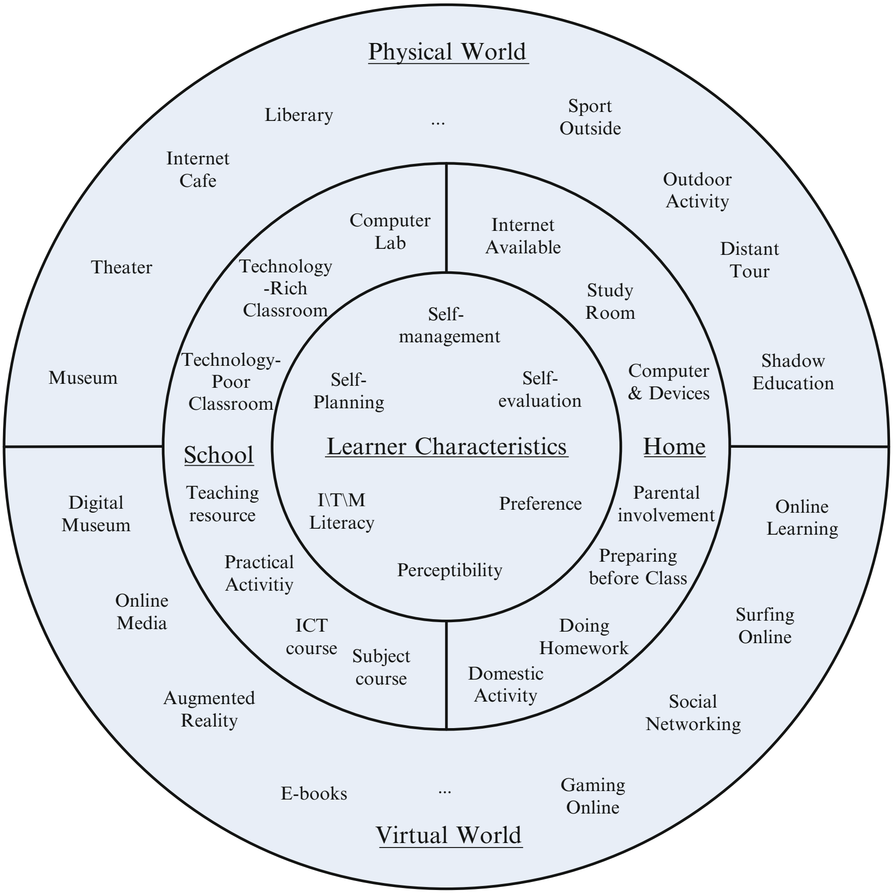

Fig. 1.2 Framework for understanding the cyber lifestyle of students

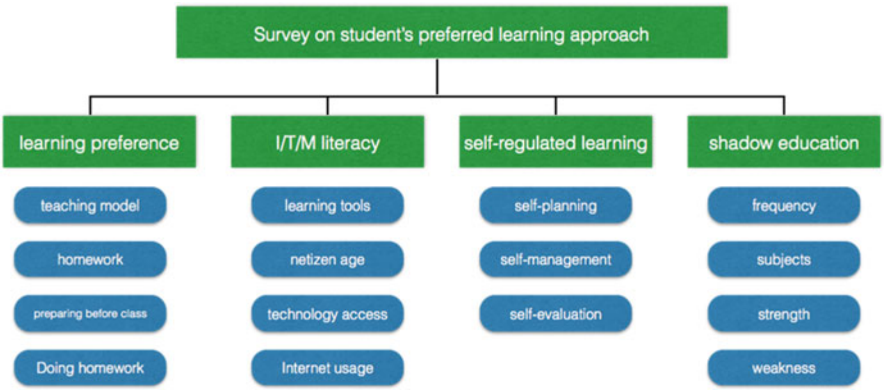

Fig. 1.3 Structure for investigation of students' preferred learning approaches

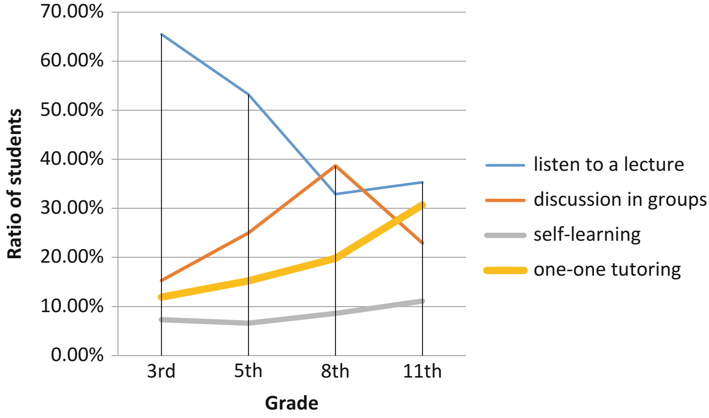

Fig. 1.4 Students' preferred learning approaches

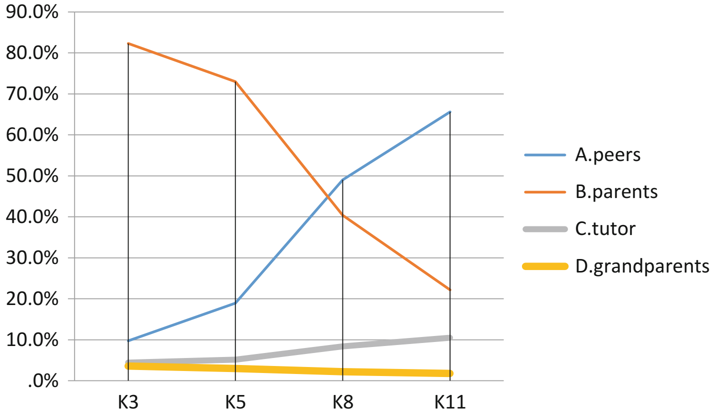

Fig. 1.5 The person who is most helpful to learning, except teachers

school indicated different learning preferences. Most primary school students preferred to listen to a lecture, while most junior school students preferred to learn through discussion in groups (Fig. 1.4).

2. Aside from teachers, 33.4 % of students considered classmates or friends to be most helpful to their learning, 57 % considered parents, 6.9 % considered nannies or tutors, and 2.7 % considered a grandparent. In primary school, parents were most helpful to students' learning; in junior middle school, both parents and peers were helpful; and in senior middle school, peers were most helpful. We could also see that the tutor was considered more helpful to senior middle school students than to primary school and junior middle school students (Fig. 1.5).

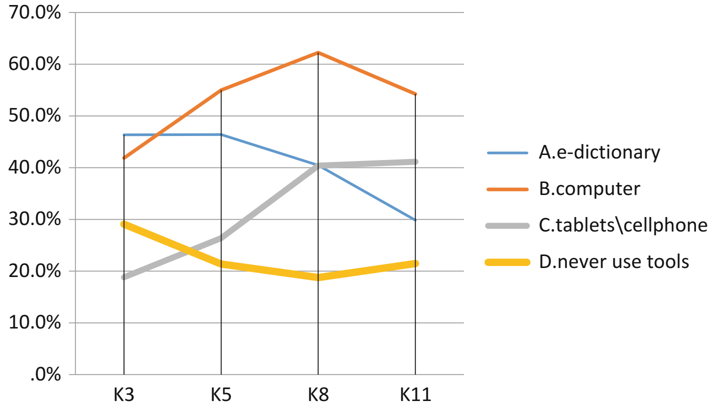

Fig. 1.6 The learning tools that student most often used

3. 47.2 % of students spent less than 10 min, and 41.2 % spent 10–20 min in self-learning or discussion in class. Grade 2 students in junior school had more chances to spend time self-learning and discussing in class.
4. 41.7 % of students often used an e-dictionary, 53.6 % often used computers, and 31.1 % often used tablets or a cell phone. The computer has become the most popular learning tool, followed by machines and electronic dictionaries. Electronic devices were still the primary learning tool for students. Younger students preferred to use machines and electronic dictionaries; seniors were more likely to use computers, tablet computers, and mobile phones (Fig. 1.6).
5. The main source of extracurricular knowledge for students comes from the Internet (56.9 %); radio and television (59.7 %); books, newspapers, and magazines (75.9 %); and from extracurricular activities (39.2 %). Most extracurricular knowledge comes from books, newspapers, and magazines; however, the Internet has gradually become the most important source of extracurricular knowledge. Sources of extracurricular knowledge vary between grades. In primary school, books, newspapers, and magazines are the main sources of knowledge; however, by high school, the Internet has become a major source of extracurricular knowledge.
6. In response to the section "The main difficulties that students encountered when using the Internet to learn", 48.3 % of students indicated that they lacked Internet skills; 39.8 % of students indicated that their self-discipline was not strong, and they were easily distracted; 22.3 % of students indicated that Internet learning resources were dull and boring; 30.4 % of students did not know who they could ask for help when they experienced problems. A lack of networking skills was the primary difficulty, followed by lack of self-control, and inefficient learning. As students advanced, so did the difficulties encountered. The main difficulties for pupils were network operation skills and techniques, while poor self-discipline and easy distraction were the main problems for seniors.

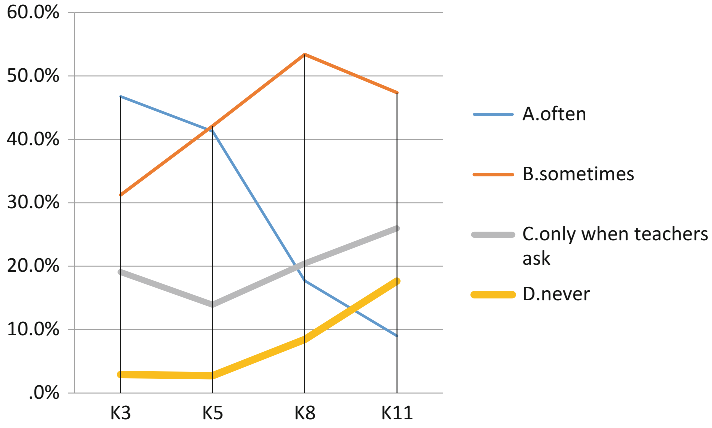

Fig. 1.7 Preparing for lessons before class

7. 30.3 % of students 'often' prepare before class, 43.5 % 'occasionally' do, 19.2 % prepare only when the teacher requires it, and 7.1 % never prepare before class. Students exhibit different preparation habits, and the frequency for preview reduced with student age. Girls applied more effort to previewing than did boys (Fig. 1.7).
8. 75.2 % of students participated in shadow education. 47.7 % of students indicated that they preferred the teaching methods, 22.5 % students liked the content, 15.4 % liked peers in the class, 14.3 % liked the teacher. Data indicated that teaching methods and curriculum content were the two most important factors to attract students.

1.5 The Learning Gap Between Digital Native Preferences and K-12 Classes Provided

We compared the differences between the preferred learning methods of digital natives and what is provided by K-12 schools. The primary issue was to identify digital natives. Procedures for this research can be divided into four steps, as follows and as shown in Fig. 1.8.

(1) We identified sampling rules for selecting digital learners (DL) who are proficient with technology, and non-digital learners (nDL) who seldom used technology.
(2) We used the sampling rules to select DL and nDL.
(3) We compared the differences between DL and nDL.
(4) We conducted focus group interviews with the students.

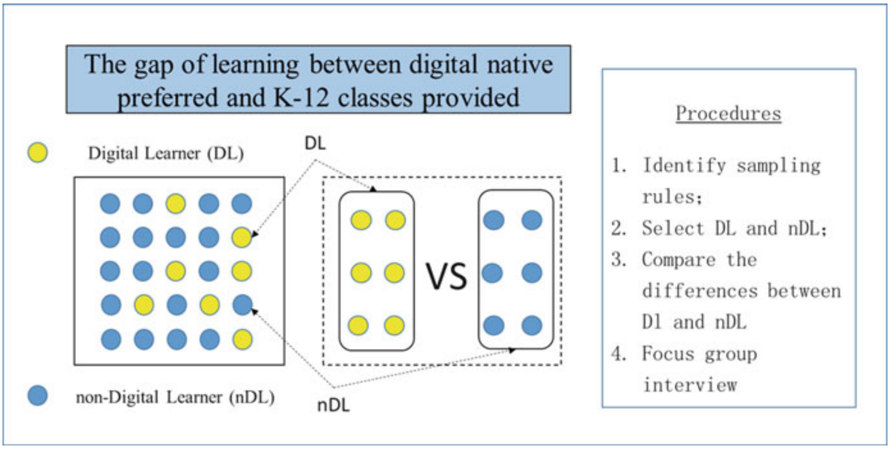

Fig. 1.8 Procedures of this research

1.5.1 Research Tools

Data were collected for this study using two questionnaires. The two questionnaires include the Digital Native Questionnaires (DNQ) designed by the researchers and a focus group interview protocol. Both employed questions developed from the research questions.

The survey enabled researchers to rapidly reach subjects and allowed researchers to employ many technologies to assist in development of the survey and the collection of results (Tourangeau 2004). DNQ questions derived from the typical feature of digital learners the researcher identified; there are a total of 30 questions.

Focus group interviews are a multi-faceted instrument that can be used alone, or in conjunction with other research methods, allowing researchers to delve more deeply into the study of a phenomenon and provide enhanced understanding to the research (Sinagub et al. 1996). The focus group questions consist of six parts, which include content sequence, materials provided, pedagogy, ICT usage, learning outcome, and assessment.

1.5.2 Results

As the digital native has grown up with digital technology, and technology was the most typical feature of the digital native, we used 'technology' details to select DL from the 28,300 students. The following four rules were used to select DL.

1. Age of netizen: K-11 students with a netizen age of 5 and over 5 years; K-8 students with a netizen age of 4, 5, and over 5 years; K-5 students with a netizen

age of 3, 4, 5, and over 5 years; K-3 students with a netizen age of 2, 3, 4, 5, and over 5 years.

2. Self-confidence in using the Internet: students who believed they were good at using the Internet.
3. Devices and access to the Internet: students who had computer access and could access the Internet at home.
4. Time spent surfing on the Internet every day: students who spent more than 1 h surfing on the Internet every day.

Following this rule, 9.0 % of grade 3 elementary students, 15.1 % of grade 5 elementary students, 12.9 % of grade 2 junior school students, and 7.5 % of grade 2 senior school students were selected, resulting in a total of 5,358 DL, of whom 3,027 (56.5 %) were male and 2,331 (43.5 %) were female.

We selected students with a netizen age of <1 year as nDL: 22.7 % of grade 3 elementary students, 16.4 % of grade 5 elementary students, 10.3 % of grade 2 junior school students, and 4.1 % of grade 2 senior school students were selected, for a total of 6,698 nDL.

We then compared the differences between these 5,358 DL (19.0 % of the total) and 6,698 nDL (23.7 % of the total).

From these comparisons, we found obvious differences between DL and nDL, in particular (1) DL relied on technology more than did nDL; (2) DL preferred to learn more collaboratively; (3) DL preferred visual materials; (4) DL were more involved in shadow education, and they preferred more one-on-one tutoring.

1. DL used the Internet to acquire knowledge after class much more frequently than did nDL, which meant the Internet had become the most important way for them to acquire knowledge after class. A total of 76.4 % of DL used the Internet to acquire knowledge after class compared with 28.2 % of nDL.
2. DL were more active than nDL in online collaboration, and a larger proportion of them made friends, posted pictures in Bulletin Board System, and browsed online social networking sites than did nDL. A total of 62.4 % of DL had experienced collaborating with others online, while 37.6 % of nDL had such experiences; 64.7 % of DL compared with 31.3 % of nDL tended to make friends online.

   DL liked collaborative learning, self-learning, and one-on-one tutoring more, while nDL liked teaching and receiving more; 28.5 % of DL versus 19.2 % of nDL liked collaborative learning; 20.6 % of DL versus 14.9 % of nDL liked one-on-one tutoring; 9.4 % of DL versus 7.3 % of nDL liked self-learning.
3. DL preferred watching videos and playing games, chatting, reading, and shopping; while nDL preferred to learn online. A total of 85.3 % of DL versus 52.3 % of nDL preferred to watch videos and play games online; 68.7 % of nDL versus 59.1 % of DL preferred to learn online.
4. DL were more frequently involved in shadow education than nDL; 75.0 % of DL were involved in shadow education more than once a week. DL liked the learning content the most, as did nDL when they joined in auxiliary classes, but DL liked the peers and one-on-one tutoring more than did nDL. 17.5 % of DL

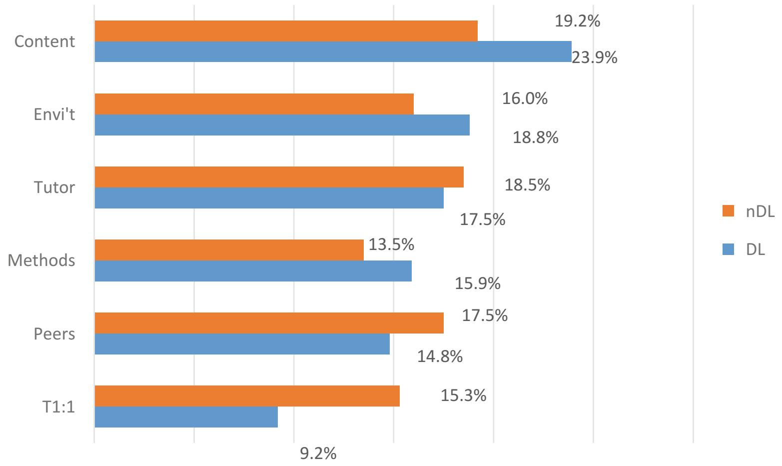

Fig. 1.9 The factors students like in auxiliary classes

versus 14.8 % of nDL liked peers; 15.3 % of DL versus 9.2 % of nDL liked one-on-one tutoring, as shown in Fig. 1.9.

DL preference for one-on-one tutoring inspired us look at the differences in learning between one-on-one auxiliary classes and school. The differences could to some extent reflect the gap in learning ways between that preferred by digital natives and what is provided by school classes. Therefore, to better understand the gap, we conducted some focus group interviews with 28 DL, comprising five K-3, six K-5, seven K-8, and ten K-11 students. The results of the interviews can be synthesized in the following five aspects.

1.5.2.1 Content Sequence

Most students thought the sequence of content in school classes was too rigid and very controlled by the teacher, while in one-on-one tutoring classes they had more choice and the teacher could change the content sequence according to their learning needs.

"First the teachers will give me a test to understand my prior knowledge, and they will choose what I should learn. For me, it saved me a lot of time to skip the content that I have mastered" (Student 01).

1.5.2.2 Materials Provided

All the students expressed that the textbooks, references, and courseware were the main materials provided by school classes; some students mentioned that some digital resources were also provided by school classes. About 16 students stated that they seldom used the materials provided by school classes, but they bought and used other materials associated with their particular needs.

"In one English one-on-one tutoring class, teachers give me a list of learning materials to allow me choose which I prefer to learn from, such as English cartoon movies, digital storybooks, flash cards, MP3 listening materials, etc. I am attracted by these materials." (Student 02).

1.5.2.3 Pedagogy

Although student-centered pedagogy has been advocated for over 10 years in China, most students revealed that classes were still teacher-centered. Teachers would adopt some strategies to meet the needs of students, while students thought most of the classes were dull and could not meet their learning needs. However, when students talked about one-on-one tutoring, they thought the teachers understood them clearly and provided the exact learning methods they needed.

"Teachers conduct many learning activities in one-on-one tutoring class, such as role playing; every time I finish learning task, the teacher will give me feedback quickly; I can ask questions freely anytime of the class; it is the real self-paced learning. Only if I understood the knowledge point, then the teacher will move on to the next knowledge point" (Student 03).

1.5.2.4 Learning Outcome

Students expressed that the main learning outcome in school classes were homework assignments to be completed after each lesson or unit, and was the same for every student, while the homework in the one-on-one tutoring class was much more adaptable to different students according to their understanding of the learning content.

"I don't like doing homework assigned by school teacher, because I could not finish these homework assignments without the help of my parents; while I like doing homework assigned by the one-on-one tutoring teachers, because the homework is suitable for my level of knowledge." (Student 04).

1.5.2.5 Assessment

School classes always use quizzes; homework quality; and monthly, mid-term, or final exams as assessment tools. In one-on-one tutoring classes, teachers highlight the shortcomings of each student, and give effective suggestions on how to overcome them.

"In one-on-one tutoring, the teacher will give me suggestions based on my learning portfolio in the classes, and the teacher will pay more attention to my learning ability and not just the examination score" (Student 05).

His classmate added, "My examination results will be compared with other students, which makes me uncomfortable; while in one-on-one tutoring, I don't need to worry about that." (Student 06).

From the above analysis, we could clearly see the differences between one-on-one tutoring and school classes in terms of content sequence, materials provided, pedagogy, learning outcome, and assessment.

By comparing DL and nDL, we found differences in their learning preferences. For example, DL preferred more socialized learning methods, visual materials, one-on-one tutoring, and relied on technology. From the focus group interviews, we found differences in learning methods between those provided in one-on-one tutoring classes and K-12 classes. Content sequence in one-on-one tutoring could be adjusted by students, and students could choose the content they needed, while in K-12 classes the content sequence was rigid and controlled by teachers with their long-term routine from the past; materials in one-on-one tutoring were provided according to students' needs, and the diversity of students was considered, while materials in K-12 classes were the same for all students; teacher-centered pedagogy was common in K-12 classes, while one-on-one tutoring was truly student-centered; learning outcomes in K-12 class were always the completion of homework and preparing for examinations, while in one-on-one tutoring, the learning outcome was always stated clearly and adapted accordingly; assessment in K-12 classes was via quiz, homework, and examinations, while assessment in one-on-one tutoring was effective suggestions for students.

There was a gap in learning methods between one-on-one tutoring and K-12 classes. We identified from the questionnaire that DL preferred one-on-one tutoring, and that it was the learning methods in the one-on-one tutoring that they preferred. So the gap in learning methods between one-on-one tutoring and K-12 classes was the gap between learning ways preferred by digital natives and what K-12 classes provided, as shown in Table 1.1.

Some may argue that the digital native only represents students who have been immersed in technology for a long time, and this research found only 6,698 digital natives among 28,300 students. It seemed we could not conclude that the learning methods preferred by digital natives indicate the direction of education reform in classroom teaching, because digital natives represent only a small proportion of students. However, we can predict that, if we used the same rules to select digital natives in 2 years time, the proportion of digital natives would have increased.

Some may argue that the criteria for selecting digital natives should be reconsidered. We found this to be true, and the sampling rules were very important in terms of the netizen age, whether '2 years' for K-3 students was suitable; for the time spent surfing on Internet every day; and whether the student who surfed online for more than 3 h should be included. In future research, the sampling rules could include more detail.

Table 1.1 Gaps between what digital natives prefer and opportunities available in K-12 classes

Dimensions	What digital natives prefer	What K-12 classes provide
Content sequence	Content sequence can be adjusted themselves	Strictly follow the textbook sequence stated for all students
	Having the opportunity to choose content if they need to	Sequence is controlled by the teachers with their personal teaching habits
Material provided	Providing materials for students according to exactly what they need	Textbooks and references controlled and provided by the Government
	The diversity of student needs should be considered	Courseware or presentations only consider one size for all
		Digital resources collected by teachers only support the need to prepare for examinations
Pedagogy	Hoping to be truly student-centered	Student-centered methods kept in the teacher's mind but class ran as teacher-centered
	Skipping over content already mastered	All students need to follow the same knowledge route based on the solo instructional strategies most teachers have
Learning outcome	Stating clearly what needs to be done	Learning outcome is only the homework assigned following the questions after each unit/module/lesson of textbook
		Preparing only for standardized examination
	Learning outcomes are adapted to different students	
Assessment	Authentic assessment for examining what they did or did not retain	Only considering the quiz in class and the homework
	More effective suggestions for their learning	Assessing with monthly, mid-term, and final exams

1.5.3 Discussion

A large gap in learning methods did exist between what the digital native preferred and what K-12 classes provided in terms of content sequence, pedagogy, learning outcome, material provided, and assessment. In the first three aspects, the differences were quite obvious, and these aspects were important for teachers to conduct a particular teaching method. In fact, to change the content sequence was most important, but it is difficult for teachers to change content sequence in common classes, because it is stipulated in curriculum standards and teachers should follow the standards. While knowledge-connected learning was regarded as one promising way for learners to learn with technology, the most urgent recommendation is for changes to content sequence.

Knowledge-connected learning is the process by which learners go from understanding knowledge sources and knowledge structures of learning objectives and gradually master the key knowledge content so as to master the whole knowledge within the specified period of time. In connected learning, learning paths were differentiated, with both linear and non-linear paths. Flexible learning methods are more conducive to fostering innovative thinking and reasoning (Huang et al. 2013; Yang et al. 2013).

The pedagogy gap originates from teachers not understanding the unique characteristics of digital natives, and teaching according to their understanding of former students. This situation is highlighted by John Dewey's famous saying, "If we teach today's students as we taught yesterday's, we rob them of tomorrow" (Dewey 1944).

Learning outcomes defined by teachers could not match the needs of digital natives because the textbooks are removed from real life and are slow to be updated.

The gap between what the digital native prefers and what K-12 classes provide highlights the challenges of education reform in classroom teaching. As we mentioned in the literature review, students' needs must be taken into account before educational change. The comparison of learning ways between what digital natives prefer and what K-12 classes provide in this paper was the analysis of students' needs in classroom learning, and highlighted the shortcomings of today's classroom teaching and the directions in changing classroom teaching.

1.6 Conclusion

This research has addressed the framework and methods for understanding the new generation of learners from the perspective of connection in the context of learning circumstances. The highlighted points of knowledge capital can be summarized as follows.

The method for understanding current students has been discussed. We hold the idea that the debate about digital learners should undergo more deep research rather than simply argue whether a new generation of learners exists. The research method should consider the policy, environment, teaching strategies, and students themselves, which composes the whole picture in which students live and learn.

A framework for understanding the cyber lifestyle of the student has been proposed, which is intended to depict the circumstances and activities that influence or reflect student's learning and living behaviors. Researchers could select the elements in the framework or add new elements to address their interest questions associated with students' learning in this information age.

A large gap in learning methods between what the digital native prefers and what K-12 classes provide in terms of content sequence, pedagogy, learning outcome, material provided, and assessment was revealed, which highlighted the shortcomings of today's classroom teaching and directions in changing classroom teaching.

Future research directions include (1) to conduct surveys based on the framework all over China rather than just in Beijing; (2) to research the design, development, and evaluation of the smart learning environment; and (3) to develop e-textbooks for the new generation of learners.

Acknowledgments This research work is supported by Beijing Digital School (BDS) program funded by Beijing Municipal Government.

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Chapter 2
Software Engineering and Modeling in TEL

Alke Martens

Abstract Very different types of systems for teaching and training based on a computer have been developed and put together under term TEL (technology-enhanced learning). Starting with Hyperbooks and Intelligent Tutoring Systems (influenced by cognitive psychology), going to other adaptive systems, embracing single-user and multiuser systems, and, in the last years, becoming mobile, a plethora of systems emerged. Surprisingly, not many of these system types have made their way to off-the-shelf products, but remained at the level of research. Moreover, the following questions can be posed: what insights have been drawn from the development of this multitude of systems. How shall technology be designed to enhance learning? One insight is that system design on the model basis has been widely ignored by the community. This results in a lack of discussable basic concepts, in systems, which are empirical, not comparable, and in system ideas, which cannot be reused. The approach sketched in this chapter shows how different levels of system design can be (and have successfully been) supported by models. These models work independent of the programming language, they can be reused for the development of (at least) some different system types, and they can be used as boundary objects for interdisciplinary communication.

Keywords Process model • Architecture model • Formal model

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R. Huang et al. (eds.), *The New Development of Technology Enhanced Learning: Concept, Research and Best Practices*, Lecture Notes in Educational Technology,
DOI 10.1007/978-3-642-38291-8_2,

2.1 Introduction

In the context of research in the field of Artificial Intelligence in Education (AIED), Baker stated a while ago: "A significant part of AIED research can be seen as the use of computers to model aspects of educational situations that themselves involve in the use of computers as educational artifacts, some of which may incorporate computational models" (Baker 2000, p. 123). One important aspect mentioned in this sentence is the mixture of different models and of different levels of modeling: models of (aspects of) educational situations are, for example, cognitive models, learner models, and models of instructional design – even models of classroom construction can be subsumed; computational models are usually mathematical models. In-between, models are used for the development of computer systems: architecture models, process models, content models, and evaluation models, to name just a few. This plethora of models is rather typical in technology-enhanced learning (TEL), also in fields, where the usage of methods from Artificial Intelligence plays a minor role. The amount of models itself is not the problem. The problem is the model reuse and the sophisticated development of TEL systems based on existing models. If models at different levels of system design would be used in TEL system development, this might lead to a situation, where:

- On the top level, different stakeholders can facilitate communication about system development (e.g., use system models or architecture models as boundary objects in communication).
- On the system development level, basic development ideas are independent of the programming language.
- On the base level, main TEL system ideas could be maintained even when the system is refactored, extended, or re-implemented.
- On a meta-level, systems might be better comparable, for example, if they are based on at least partially the same models. This results in systems which can be used as a basis for empirical evaluation.

Usually, these are the basic insights in computer science, which lead directly to software engineering. But how have we come to the idea that there is something like this missing in TEL system development?

Several years ago, we developed the Intelligent Tutoring System (ITS) "Docs'n Drugs – The Virtual Hospital" (Martens et al. 2001). The first idea has been to reuse parts of existing systems, as our main research question has been the construction of an adaptive tutoring process for case-based learning. What we did not want is to implement an ITS of scratch. However, after checking the state of the art, we found that we had to partly reinvent the wheel. Our state-of-the-art analysis comprises ITSs and theoretical descriptions of the ITS architecture (e.g., Alpert et al. 1999; Anderson et al. 1990; Corbett et al. 1997; Lelouche 1999). The results of the analysis are the following:

- The ITS core architecture is more or less fixed and still valid today (Martens and Uhrmacher 2004). The classical architecture can be traced back to Clancey, who has described it in the 1980s (Clancey 1984). It consists of four models, that is, learner model, expert knowledge model, pedagogical (knowledge) model, and user interface.

- Whereas the architecture is fixed, the realizations vary. These variations are not only due to technical demands (e.g., pedagogical agents (Kuenzel and Haemmer 2003) or simulations (de Jong and van Joolingen 1998), (Kuenzel and Haemmer 2003)) or based on domain specific aspects (e.g., grammar (Mayo et al. 2000) vs. medicine (Bergin and Fors 2003)). They also seem to have an evolutionary aspect (e.g., evolution of the expert knowledge model from a mere database model in MYCIN to a knowledge model in GUIDON (Clancey 1987)). Even if the main architecture is based on Clancey's description, the role and functionality of each of the modules is flexibly adapted to what is currently needed (see also Martens and Uhrmacher 2004; Oertel et al. 2008).

Even from the perspective of our research in the late 1990s, when we implemented the first ITS, these insights were surprising, as one idea about developing different sorts of ITSs for the same application domain should (scientifically seen) be to enhance the system's functionality, and not just to re-implement existing ideas. But if we have to re-implement a system from scratch, the new system is basically no longer comparable to the older ones. Moreover, how could existing approaches be (technically) evaluated if their core functions are not explicated? Also, this was the time of upcoming discussions about software engineering, object-oriented design, and the target goal of all complex applications: reusability and structures, which are easy to communicate. Both claims of state-of-the-art software cannot be met with most of the ITSs of the last years!

Regarding other TEL systems, the situation is even worse: game-based learning systems are based on totally different core concepts, most of which are not explicated; adaptive systems suffer from the same problems. When it comes to changing the device, for example, from laptop to cell phone, to mobile applications, the applications are discussed, sometimes also the client-server structures, but seldom the system architectures or the system components.

The result of our investigations led to the following:

1. We had to implement the ITS Docs'n Drugs from scratch (Illmann et al. 2000). The system was first used and tested at the University of Ulm and is still running as part of the medical curriculum. Due to the strict model-based development, the core system has later been extended, refactored to component-based design, and used as the basis for a framework, which is then used as basis for different new (intelligent and not intelligent) teaching and training systems.
2. Based on our analysis of ITS architectures, we started to collect and define patterns of ITSs (Harrer and Martens 2006). Together with working groups from other universities (e.g., Harrer 2003; Schuemmer and Lukosch 2007), we have collected a large amount of patterns for computer-based teaching and training systems (aka TEL) and constructed a generic pattern catalogue. The catalogue starts with project management patterns for TEL (e.g., Martens et al. 2009), comprises architecture patterns (e.g., for ITS and game-based TEL

systems (e.g., Maciuszek and Martens 2010) and genre patterns for games (e.g., Maciuszek and Martens 2011) and for cognitive modeling (e.g., Maciuszek and Martens 2012, 2013), and finally leads to the programming level as, for example, architecture patterns are related to software patterns (based on Gamma et al. 1995).

3. One step further, we have developed a formal description (a formal model) for the central steering component, in our terminology called the tutoring process model (TPM) (e.g., Martens and Uhrmacher 2004; Martens 2006). The advantage of the formal TPM description can be seen in the language independency and in the abstraction from any content. The formal (mathematical) description can be used as the basis for implementing adaptation processes in TEL (Martens 2005).
4. We have developed the JaBInT framework – Java-Based Intelligent Tutoring. Based on the concept Plug'n Simulate realized in JAMES II (Himmelspach and Uhrmacher 2007), our goal was to develop a Plug'n Train concept. The main idea was to provide a core set of components and integrated modules. The core set provides the main functionality and the basic interfaces. By implementing additional modules, the core functionality can be extended – new modules can be "plugged" into the existing components. On the long run, the (admittedly ambitious) result should be a toolkit for different TEL systems.

Figure 2.1 sketches three of the mentioned system design levels and the according models, as sketched above. The topmost level shows an excerpt of the process model used for TEL system development, the mid-level shows a sketch of the ITS core structure, and at the base level, a short extract of the tutoring process model can be seen.

2.2 Modeling the System: The Basic Architecture

In this chapter, we use four major terms: model, framework, component, and module. The model is an abstract description of something, for example, the formal tutoring process model, the architecture model, or the component model. The components are software components (e.g., Szyperski 2002). They are part of a composition and can be independently deployed by other software developers. Component models describe each component's basic structure, its interfaces and communication channels. The main system functionality is provided by a set of core components, which form the framework. On the software level, concrete and abstract classes realize the basic functionality (e.g., the plug-in mechanism). The abstract classes consist of concrete and abstract operations – which define the interfaces. New components must implement these interfaces to extend the basic functionality. In our approach, the components additionally consist of modules. The modules provide additional functionality. Due to our goal to provide maximum flexibility, the core components can be exchanged as well, but mainly, new functionality will be plugged into the system by adding or exchanging modules.

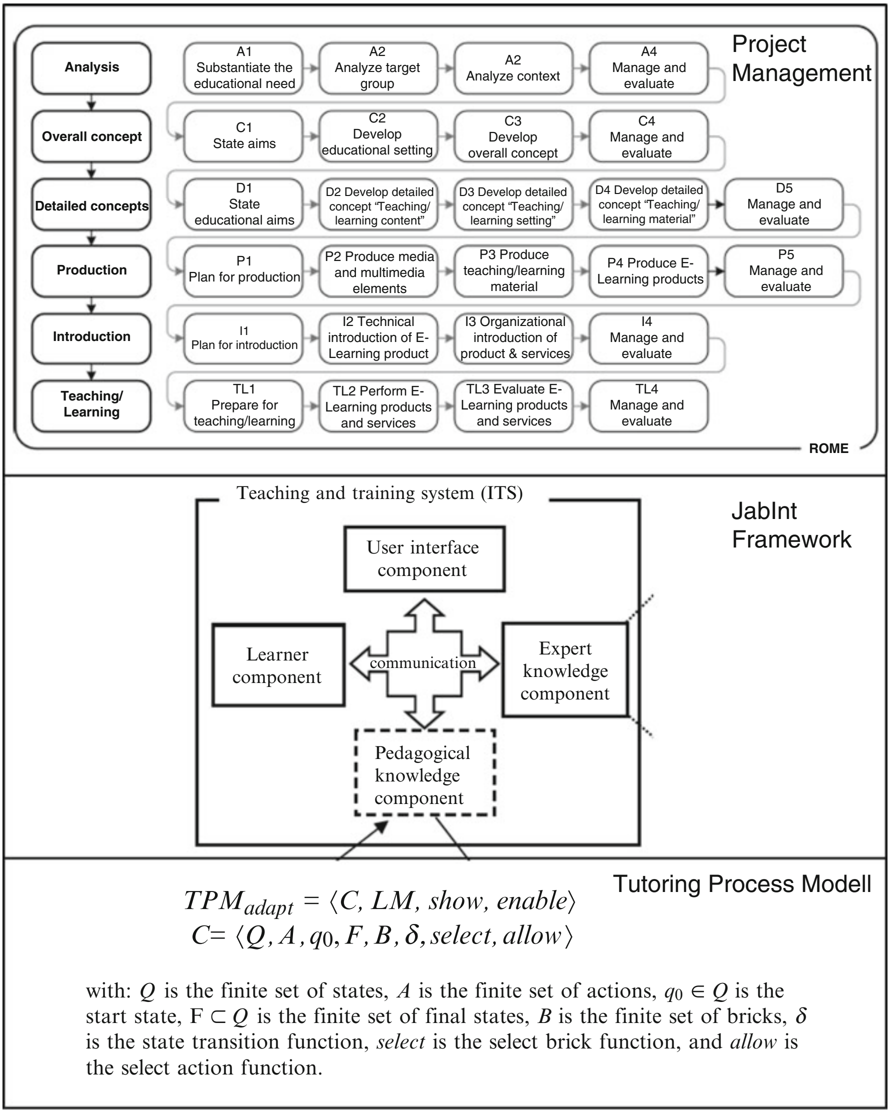

Fig. 2.1 Models at different levels of system design

According to the results of our analysis of (intelligent) TEL systems, the set of core components are as follows: user interface component, knowledge component, (pedagogical) process steering component, and learner component (see Fig. 2.2) (the underlying models are user interface model, knowledge model, process steering model, and learner model, respectively). The basic architecture has its equivalent in the pattern description (see, e.g., Harrer and Martens 2006). To have a better level of abstraction, we have later put together all knowledge models (e.g., expert

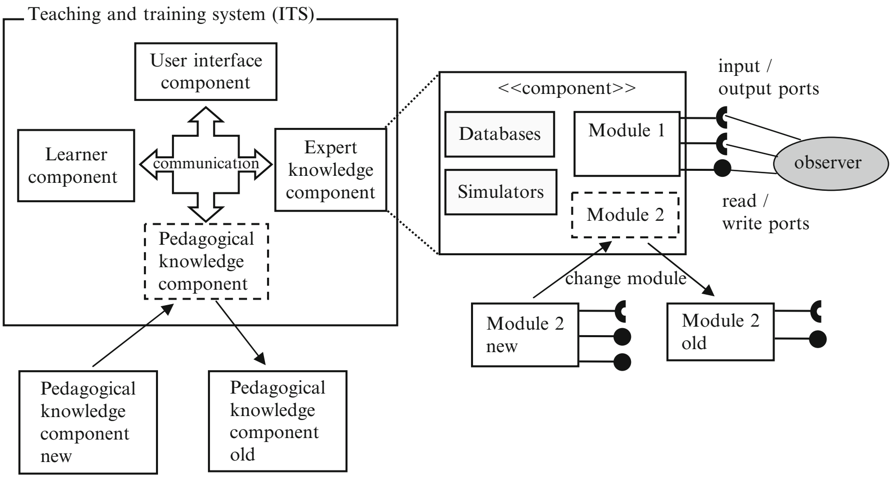

Fig. 2.2 Relation between system, project, components, and modules (See Maciuszek and Martens 2011. Adapted from Oertel et al. 2008)

knowledge and pedagogical knowledge, as sketched in other ITSs; see Sect. 2.1) in one component. All the knowledge about adaptation functionality, temporal aspects, correction, and feedback functionality is described in the (formal) tutoring process model and realized in the so-called process steering component. The latter is thus responsible for steering the learning/teaching process.

Figure 2.2 shows a sketch of the basic architecture of the framework. All components can communicate with all other components (which is depicted by the central abstract communication arrows in Fig. 2.2). The core architecture can be found at the left side of Fig. 2.2. On the right side, the (expert) knowledge component has been enlarged (to give an example). In Fig. 2.2, an exchange of modules is depicted exemplarily on the right side. In the lower part of the figure, an exemplary exchange of a component is sketched. The only restriction is that a component can only be replaced by a component of the same type.

As can be seen at the right side of the Fig. 2.2, the component is realized as a kind of frame, which contains several (and at least one) modules. In literature, two basic ways have been found to develop a knowledge component: either the component is realized as a more or less complex database (e.g., Martens et al. 2001) or the component's functionality is provided by a set of models with other functionality (e.g., Michaud et al. 2000). Modules are completely independent from each other, so that the replacement of modules has no side effect. Each module contains *use* interfaces realized as input and output ports.

Observers monitor the occurrence of events in the components. They steer the data transfer between the modules (via input and output port couplings). Plugging of components works by registration and the definition of a "project," which records all components of an application, their couplings, and their communication structure.

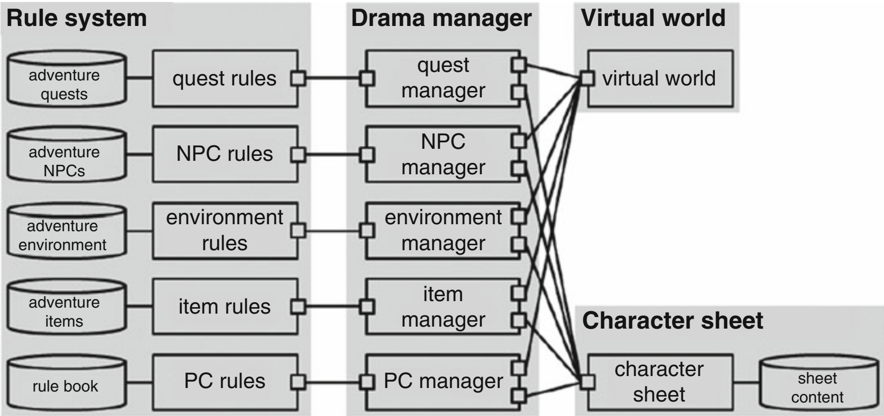

Fig. 2.3 Transfer of ITS architecture to game-based learning (From Maciuszek and Martens 2012)

As shown in Fig. 2.3, the architecture can directly be mapped to other system times. We have exemplarily transferred the architecture to the domain of game-based learning (or even to pure games), especially for role-playing games (see Fig. 2.3). Here, the expert knowledge base becomes the rule system, internally (at least logically) separated into parts like rulebook, adventure items, etc. The user interface is provided by a virtual world. The learner component in the game is the so-called player character (in role-playing games, this is comparable to the character sheet), and last but not least, the central steering component (i.e., the tutoring process component) becomes the drama manager (the internal separation in logical parts reflects the logical parts in the knowledge base).

2.3 Modeling Interaction and Adaptation: Tutoring Processes and Cognitive Tasks

The core question of adaptive software is always related to user knowledge modeling: how much can a system automatically grasp given only an assumed set of knowledge items in advance plus the current activities of a user? This includes how to deal with uncertainty (Jameson 1996), how to model the underlying knowledge, and how to interpret the learner's activities over time.

The fundamental idea of our approach is rooted in two very similar approaches, the first of which comes from computer science and the second one comes from cognitive psychology. In computer science, especially in the development of Intelligent Tutoring Systems, we have the tutoring process model (TPM) (Martens 2005). Intelligent Tutoring Systems have two major aspects: they are based on extended expert knowledge bases, which usually provide facts and rules of the application domain, and they automatically adapt to the learner's performance. The TPM is an automaton-based formal model, which describes how the adaptation process takes place using two sources of information: (a) the learner's current state of knowledge and (b) the learner's choice of next steps in the training system. The training content (e.g., in case-based training the training scenario) is divided into states and actions. An action leads from one step to another. The learner's current state of knowledge in the training case is based on the states he has visited and the actions he has chosen. The learner model contains the so-called learner knowledge, which is just a collection of facts. The learner model is updated after each selection of action and after each state. There are two levels of adaptation: the first level is the selection of content displayed to the learner. Each state consists of at least one or more content elements, which have pre- and post-conditions. Given the items in the learner knowledge and the content's precondition, the content elements are selected. Similarly, on the second level, the actions are selected based on the learner knowledge. Actions have pre- and post-conditions. Given the learner's knowledge, the actions are selected. Post-conditions of both the displayed content elements and the displayed actions are recorded in the learner knowledge. A more detailed description (and the formal model itself) can be found, for example, in Martens (2005) and several other publications.

In cognitive psychology, we have the knowledge space theory (Doignon and Falmagne 1999), having its roots in test theory. The knowledge space theory has later been extended by various researchers. The basic idea regarding the learner's knowledge is that we have a knowledge space, reflecting the prerequisite relations, and the learner's knowledge state, reflecting the subset of problems the learner currently can solve. Albert et al. extended the approach by distinguishing skills and competencies (Heller et al. 2006). This has led to the competence-based knowledge space theory (dito). Albert et al. were among the first to use knowledge spaces for the description of the user's progress in game-based learning (Albert et al. 2007). Similar to the approach described above, the competence-based knowledge space consists of problems and learning objects. A set of skills extends the model: skills are relevant for solving problems and skills are mediated by the learning objects. Competency structures are given by sets of skills.

In the abovementioned approach of the central TPM, the modeling of the learner's knowledge is way too coarse grained. Thus, we have taken up the approach by Albert et al. and extended the TPM: in the current state of the TPM, pre- and post-conditions are only based on facts and rules based on the underlying knowledge model. Such facts might be as follows: fact is part of learner's knowledge (or not), fact in the learner's knowledge is equivalent/bigger/smaller than a certain value, facts a and b are part of learner's knowledge, and so forth. Another differentiation is to have an amount of learner knowledge and of learner's skills. This is, for example, relevant in the domain of game-based learning. Here, the learner "knows" certain facts and rules, and he is able to "do" certain things (e.g., crafting). Whereas the things the learner knows are related to his lifetime in the virtual training system or game, his skills can reflect either aspects of his virtual character or aspects of the real person. For example, a virtual player figure might have crafting skills but no magic skills. Comparably, a student of medicine in real life might have beginner's diagnostic skills.

In the description of the TPM's development (Martens and Uhrmacher 2004), this is sketched as two cognitive processes: the process of diagnostic reasoning and the process of general knowledge application (see also Martens 2003). The learner's skills extend the idea of diagnostic reasoning, whereas the classical learner knowledge reflects the general knowledge application.

For example, in a role-playing game, the learner can collect the recipe for preparing a certain juice for healing companions. To be able to prepare this juice, he must have basic alchemist skills (e.g., sketched as alchemist skills level 1), he must possess a certain amount of fruit and water for preparing the juice, and he must be able to access an alchemist laboratory. Potentially, finding the fruit also needs certain skills, whereas buying the fruit (if possible) requires a certain amount of money. Moreover, accessing the alchemist lab might require the "alchemist skills level 1" as precondition. More formally, in the learner model's knowledge, the facts "fruit, required amount" are prerequisite, same as "water, required amount," the facts and rules for "juice for healing recipe" (e.g., fruit a, 10 pieces, water, 2 buckets, alchemist lab equipment, mix fruit + water, let the mixture cook in alchemist's pot for 1 h), and the skills required for preparing the juice, for example, "alchemist skills level 1." After the juice is successfully prepared, the learner's knowledge and skill base are extended: the learner now knows "preparation healing juice." This might raise his level of alchemist skills. Moreover, the learner now has "basic healing skills," as he possesses a healing juice and the knowledge how to successfully prepare it. How to model facts and rules in the application domain (e.g., fruit, water, recipe) is part of the knowledge model or the domain knowledge ontology. To add the level of skills and competencies might be an interesting step toward micro adaptation and learner support.

Mapped to the non-game-based environment, for example, intelligent tutoring in the medical domain, skills can relate to the finding of differential diagnoses, surgery, laboratory examinations, technical examinations, and the like. In all the cases, where the physician does not have the required skills, he must call a colleague or another expert for support. Otherwise, some skills might be part of the training itself, for example, the diagnostic skill, but also the skill to prepare a surgery.

2.4 Prototypical Realizations

As a first test, we implemented a small ITS, called ChemNom (Oertel et al. 2008). Herein, students of chemistry or pharmaceutics can train their knowledge about atomic structures and chemical nomenclature in the field of organic chemistry. The learner has a set of atoms and a set of bonds (i.e., bonds between the atoms). By drag-n-drop, the learner can take atoms and bonds and construct a chemical structure in the editor field. The tutor asks for the structure of a certain chemical element. Based on the knowledge component and the (chemical) expert knowledge in the database module (i.e., facts and rules related to organic chemistry, like atoms, bonds related to atoms, exceptions, and the like), the virtual tutor (realized as a module in the process steering component) gives correction, feedback, and help and also tries some sort of motivation (on a textual basis).

Summarizing, the JaBInT framework for ChemNom consists of the following components and modules (all realized in Java and XML). The process steering component contains two modules, which are the module *preparation* and the module *evaluation*. *Preparation* contains functionality for adaptive selection of the task to be solved (adaptation to the learner's knowledge in the field and his performance) and for the presentation of the task. *Evaluation* is responsible for reacting on the learner's demands (e.g., correction or help) and for evaluating the learner's solution. The expert knowledge component contains only the module *knowledge data* as an interface to the chemical facts and rules contained in the related database. Communication with the database takes place via SQL, and results are displayed based on Java. The data structure is realized in a way that equivalent or similar chemical structures can be detected and correctly evaluated. The learner component also contains only one module, that is, the *user data* module. This module contains also an interface to a database – in this case to the learner database, which contains the user's profile. The profile is a small set of information about the learner, consisting of username, number of tasks solved, number of errors in each try, and number and id of help. The user interface component contains the user interface module. An additional module is the *event timer*, which checks and evaluates temporal delays and inactive phases of the user.

In ChemNom, 28 unidirectional couplings between ports have been realized. For example, if the learner clicks on "help," the user interface directs this to the evaluation by using the coupling "help request." In Ruddeck and Martens (2010), we reused an abstraction of these coupling to describe some communication patterns (i.e., very typical couplings), which lend themselves to steer the communication between potential modules in other TEL systems.

To show that exchange of modules is comparably easy, we changed the classical problem-oriented ITS to a game-based ITS. For this purpose, the knowledge component with the related modules can stay as is, also the process steering component and the learner component. The user interface modules are replaced by new modules. The only restriction is to somehow keep the original communication channels, that is, the new modules must provide the same input and output ports. We added a module for interactive Flash (Adobe) animation for the user interface. The communication between Flash and Java is realized in XML via a socket server. The game is based on the Tetris idea. In the interface's lower part, a list of molecules can be seen. Dropping bricks contain a name of a chemical molecule, for example, propene. The user's task is to steer the brick with the name to the correct molecule structure in the window's lower part (using the arrow keys). Color coding informs the user about his success: dark color means correct, light color means wrong (in the original interface: green and orange). Bricks pile up and form stacks. Only after a number of correct answers, a row of bricks is deleted.

Based on the abovementioned game-based transfer of the core architecture, we have then started to develop serious games and game-based learning systems. One example uses Open Sim and realizes the predator-prey differential equation embedded in a serious game story environment (the learner is a researcher on a research vessel and can observe his environment). In a small part of the story, the learner/player should understand the behavior of a fish population, which suddenly appears next to the vessel. He can see red fish and green fish, the amount of fish changing over time. The player has some devices to choose. He can feed the fish (red or green or both), and using different fishing rods, he can reduce the amount of red and/or green fish. After some time of observation and experimentation, the player is visited by another (advanced) researcher (a non-player character), which is also on board of the vessel. He asks about the player character's observations. Later on, both participate in constructing an according mathematical model for the fish population, which results in the predator-prey differential equation (Lotka-Volterra).

2.5 Conclusion and Outlook

In the approach described in this chapter, the research of many years in the context of TEL in general (ITS and game-based learning in particular) has been put together in an overview. Our approach comprises different levels of system modeling, following the claim of system engineering instead of reinventing the wheel again and again.

The first level sketched in this chapter is related to modeling the system: based on design patterns, the basic model of a computer-based instructional system is described. The usage of the same underlying system model has proved to be usable for different system types, for example, ITS, game-based learning system, and classical eLearning System. The implementation in the Plug'n Train system concept led to a reusable environment and a clear system design. The resulting system is continuously growing over time.

The second level is related to modeling the interaction and adapting to the learner. Different ways to model interaction and adaptation and the relation to user knowledge modeling are sketched and supported by examples.

On the third level, which is not further explicated in this chapter, we find the modeling of the content shows a way how a model of the teaching and training content can be used in the form of boundary objects. Here again, patterns will be used to show how the underlying system idea can be communicated to noncomputer experts which are the content developers and, vice versa, how instructional ideas can be communicated to computer science experts who have to transform this into system structures. The underlying ideas and concrete examples are sketched, for example, in Martens et al. (2009).

Regarding the concrete TEL systems, realized based on the sketched ideas, we find the following: the described ITSs ChemNom and ChemisTris are running and both are currently used in the context of other projects. Both systems will be part of a virtual lab that is currently being developed in the domain of scientific marine research and in chemistry education at the university. The approaches are using the JaBInT framework. The larger projects are also working with software engineering techniques and careful system design. Each module developed and each change to the component will be analyzed for potential abstraction. Thus, one side effect will likely have a larger set (or even library) of (abstract and concrete) modules for the framework's components. These modules can later be used as building blocks, for example, as parts of an authoring system or development environment for (component-based) ITS.

Next to developing a continuously growing set of modules for our system, we now have to follow the task to develop an authoring system based on the JaBInT framework, which allows noncomputer science learning experts and teachers to easily develop learning content for TEL systems. Additionally, we are currently working on the different levels of empirical evaluation of computer-based teaching and training systems, taking different teaching and training ideas into account same as different system designs and adaptivity.

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Chapter 3
Design of Technology-Enhanced Learning Environments That Connect Classrooms to the Real World

Masanori Sugimoto

Abstract In this chapter, we developed several technology-enhanced learning environments and evaluated them in a school setting. We describe some of these environments, which can connect classrooms to the real word. Key concepts are introduced related to the design of these learning environments. Example systems based on the key concepts are also described. The lessons learned during educational activities using the proposed learning environments are discussed.

Keywords Educational activities • Integrating physical and virtual spaces • Physical interaction • Robot

3.1 Introduction

The penetration of information and communication technology into our society has led to proposed new learning environments based on this technology and their introduction into school education. These learning environments affect the provision of instructions and learning in classrooms. Thus, the traditional "broadcasting" teaching style from teachers to students is changing into a peer-to-peer or bidirectional style.

Previously, we investigated technology-enhanced learning environments that connect classrooms to the real world (Sugimoto 2008). The targets of our investigation included helping students to discover learning issues and problem solving in a self-directed manner by increasing the motivational levels of students and amplifying their learning experiences. To achieve these goals, we designed and developed several systems that allow students to interact with physical items,

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R. Huang et al. (eds.), *The New Development of Technology Enhanced Learning: Concept, Research and Best Practices*, Lecture Notes in Educational Technology,
DOI 10.1007/978-3-642-38291-8_3,

including robots, in an immersive environment by integrating physical and virtual spaces (Sugimoto et al. 2004; Yamaguchi et al. 2009; Mi et al. 2010). These systems were evaluated during educational activities in Japanese primary schools.

In this chapter, we discuss key concepts related to the design of our proposed learning environments and we describe two example systems. The first system is called GENTORO (Sugimoto 2011), which supports storytelling by children using mobile augmented reality environments. This system allows students to design and represent their own story in a physical space by using a robot as a story character in a collaborative manner. This system aims to enhance the imagination, linguistic skills, and logical ways of thinking of students through physical interactions. The second system is called RoboTable2 (Sugimoto et al. 2011), which allows students to perform simple robot programming tasks on a multi-touch tabletop platform. This system helps students to create physical learning content using a robot so they can learn about complex phenomena such as traffic jams and explore better traffic design plans to solve problems by trial and error. These systems were designed and implemented by our group and were deployed and evaluated in school settings. We discuss the lessons learned during the design, development, and evaluation of these learning environments, which connected classrooms to the real world.

3.2 Key Concepts Related to the Design of Learning Environments

In our project, we investigated learning environments that allow students to participate actively in learning situations rather than being passive information recipients. To make students active, the learning environments need to support learning so that problems can be discovered and solved in a self-directed manner (Fischer and Sugimoto 2006). We also believe that an effective method for helping students to understand subjects is to design and enhance learning experiences so the students can subsequently memorize and reflect on their activities. Thus, we designed learning environments based in classrooms, which connect with the real world in the following ways.

- Design of curricula to contextualize learning

To fully utilize learning support systems, they should be embedded in learning situations in a contextualized manner. Therefore, it is necessary to design the systems and the curricula where they will be used. Thus, we designed an example curriculum in collaboration with schoolteachers, which aimed to provide education related to environmental problems using the following components: (1) schoolteachers were asked to teach related concepts or the subjects to be studied using textbooks, (2) outdoor fieldwork was conducted by students in areas neighboring their school to allow them to identify the problems that they wanted to investigate, (3) the students were allowed to represent their problems using a learning support system and could test their ideas by solving them in a physical space, and finally (4), the students were asked to reflect on their activities and exchange their ideas through discussions (Sugimoto et al. 2003). This contextualization approach could motivate students and make them more aware of the explicit targets of their activities in the curriculum.

- Social interaction via embodied participation

Allowing students to manipulate and interact with physical items, including robots, or sharing them with other students in a learning environment, can increase their level of motivation and their commitment to a learning situation (Kanda et al. 2004). To stimulate discussions and social interactions among students, the learning environments should be designed so they can enhance embodied participation in a physical space.

- Learning experiences that integrate physical and virtual spaces

To enhance learning experiences, we designed learning environments using augmented reality (AR) technology (Sugimoto 2008). Thus, students could receive feedback in immersive learning environments by extending the physical space with dynamic overlays of appropriate visual and auditory information using AR technology.

- Participatory design for students

While several proposals or guidelines have been made for the design of user interfaces in desktop environments, the design of learning support systems for younger children or in schools is still an important research issue. At present, there are still no recognized guidelines or theories of physical interface design in this area. When designing a nondisruptive system that helps students to concentrate on learning, it is important to ask stakeholders including students and schoolteachers to participate in the learning environment design and development processes. In our previous project (Sugimoto et al. 2002), children participated in the system design process to clarify its requirements. These participatory design processes were informative for developers because they helped to make the systems easy to use and they also facilitated the discovery of new design solutions (Guha et al. 2004).

3.3 Example Systems

3.3.1 GENTORO

3.3.1.1 Overview

In Japanese elementary school classes, children are asked to become individual characters in a given story and to read their words out loud while imagining their feelings and understanding the scenes in the story (Japanese Ministry of Education

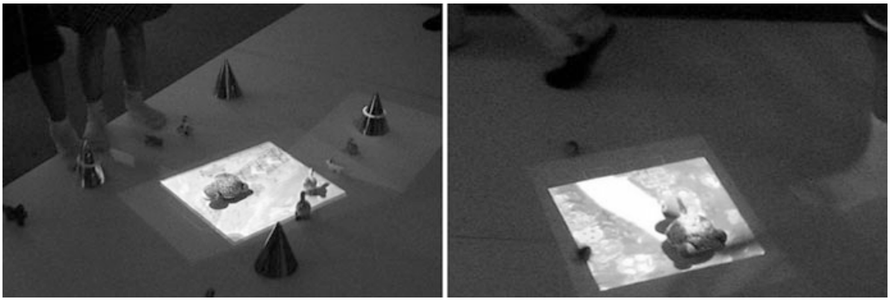

Fig. 3.1 GENTORO supports storytelling by children in a physical space using a handheld projector and a robot

2008). These storytelling activities are effective for developing the capabilities of children, such as linguistic skills, logical thinking, communication, and imagination (Wright 1997). However, we believe that if children could create their own story and express it visually and aurally in a physical space as if they were producing a film, it might be more effective in enhancing the creativity and imagination of children. In GENTORO (Fig. 3.1), children collaborate to create an original story by themselves, which they express dynamically in a physical space by manipulating a robot via handheld projectors. The features and effects of GENTORO can be summarized as follows.

- Children can express their story in an immersive environment where physical and virtual spaces are integrated using mobile AR technology.
- Children can use a robot that acts in a physical space as a character in their story, so they can express the story as if they were producing a film.

3.3.1.2 Storytelling Using GENTORO

The storytelling activities of children using GENTORO are divided into three processes, as shown in Fig. 3.2. These comprise the story design process required to write a script for the story, the story rendering process, and the story expression process required to communicate the story in a physical space.

During the story design process, children brainstorm and discuss the theme of their story, its plot, and the characters. A character in their story is played by a physical robot. Based on the story script, decisions are made about the words spoken by the characters, the narration, and rough sketches are made of individual scenes, which are then visualized graphically using a handheld projector. During the story rendering process, children draw detailed sketches and specify the behavior of the robot, including how it should move within a scene and what should happen if the robot approaches or collides with a virtual object in the scene. The children

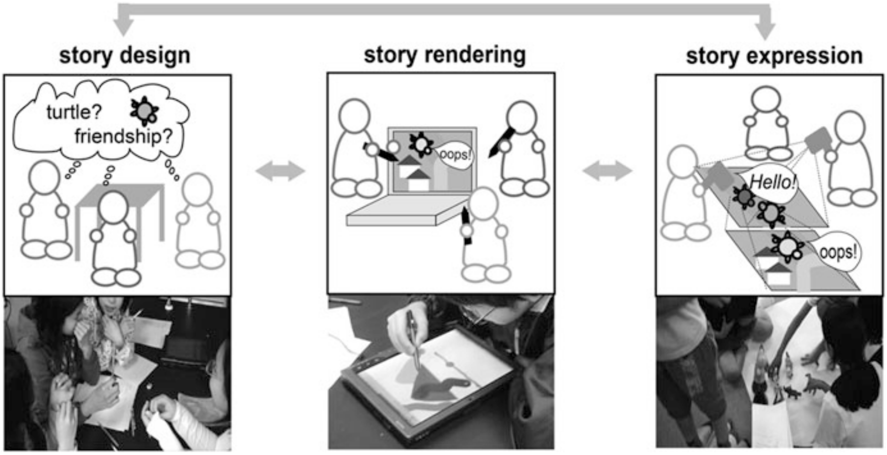

Fig. 3.2 How children perform storytelling activities using GENTORO

then conduct simulations on their PCs to confirm the rendering of their story, to improve the scene drawings, and to develop the robot movements to make their story more impressive. Finally, during the story expression process, the children actually manipulate the robot and express their story using a handheld projector, which projects graphical images as the story scenes.

3.3.1.3 Design of GENTORO

Two pilot studies were conducted to define the explicit requirements needed to support the story expression process (Fig. 3.3). In the first pilot study, the following main issues were investigated:

- The problems or difficulties experienced by children when using a handheld projector to control a robot and to display visual information, as well as solutions
- The advantages and disadvantages of multi-robot control

Based on the first study, we determined the appropriate size for the display projected onto the floor to make the scenes or text easy to read and addressed the difficulties children experienced when controlling multiple robots using a single projector and other issues.

In the second pilot study, we also investigated several issues related to specific design requirements for children, such as how to support their story rendering process. Initially, we used a tablet PC to draw the scenes. However, children preferred to draw with a pen and paper, before scanning their drawing so it could be projected as a story scene. The design requirements for GENTORO were specified based on the results of these two pilot studies.

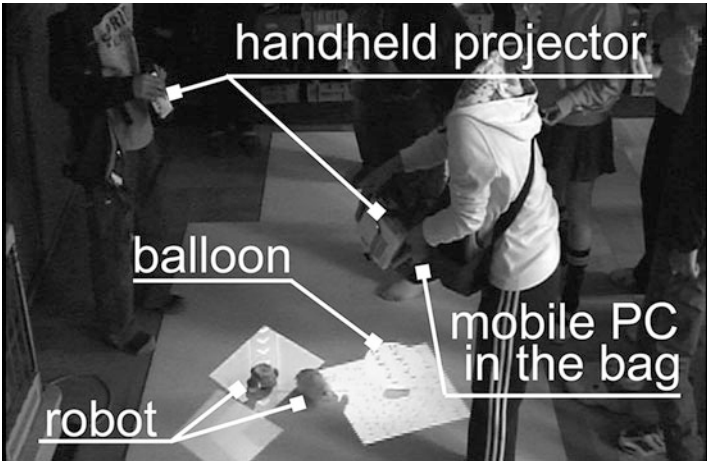

Fig. 3.3 Three children manipulating two robots simultaneously in the first pilot study

3.3.2 RoboTable2

3.3.2.1 Overview

Many techniques have been proposed for programming by novice programmers or children, including robot programming (e.g., Resnick et al. 2009; Frei et al. 2000; Gallardo et al. 2008). One difference between these existing methods and the proposed programming environment, RoboTable2, is that the latter allows students to program robots in an intuitive manner by grasping and moving them, as well as by making figure gestures on a tabletop platform. Another difference is that the proposed environment allows a student to manipulate physical and virtual items simultaneously. To the best of our knowledge, this is the first robot programming environment to use this format.

RoboTable2 was designed to help students with their robot programming tasks and to create physical contents for learning in a self-directed manner, including robots and tangible objects (Fischer and Sugimoto 2006). To create these contents, the students perform simple robot programming tasks. Supporting programming tasks is not easy because it involves several issues, such as the user interface (easy to use) and the students' comprehension of logical concepts (e.g., conditional branching and repeating). The students may also lack previous experience with using computers or programming knowledge, which means that it is necessary to provide students with a programming environment that makes it easy to create a program to control the behavior of a robot.

Using RoboTable2, students can easily create a program, e.g., they can define the intended behavior of a robot by grasping it directly and moving it on the tabletop surface. It is also possible for a learner to create simple conditional statements (e.g., "if a robot collides with a virtual wall") or other control structure statements

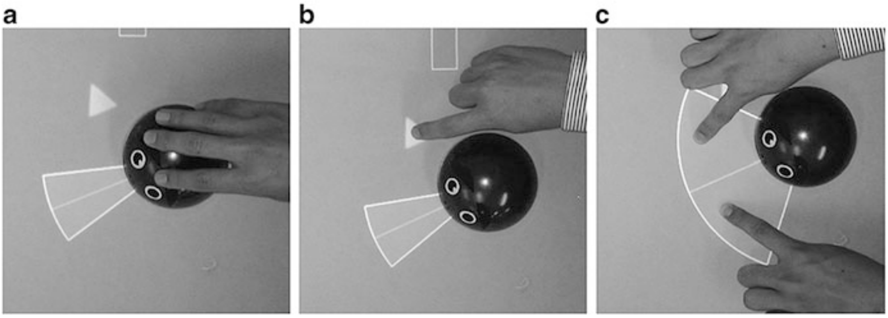

Fig. 3.4 Input techniques with RoboTable2: (**a**) “grasp and move,” (**b**) “touch,” and (**c**) “resize and reshape”

by manipulating a virtual item, which is displayed on the table using finger gestures. Therefore, RoboTable2 is expected to lower the barriers to programming for children who have little or no programming experience.

3.3.2.2 Robot Programming Using RoboTable2

Students can create a program using RoboTable2 via “grasp and move” actions or finger gestures, as shown in Fig. 3.4. First, they define an event, then a robot behavior, and finally they create a program block. Students can create program blocks repeatedly until the robot is controlled in the desired manner.

First, a student specifies the sensing area where a robot can detect a physical or virtual object. As shown in Fig. 3.4, a student can change the radius and the angle of the sector-shaped area visualized around the robot using “resize and reshape” actions. If the student makes the radius longer and the angle wider, this can increase the robot’s capacity for detecting an object.

For example, let us assume that a student wants to change the behavior of a robot when it detects a virtual wall at the right direction. First, the student grasps the robot and moves it close to the wall, or drags the wall into its sensing area. When the wall is within the sensing area of the robot, RoboTable2 identifies that the robot has detected the wall. Next, RoboTable2 automatically displays a window, which describes the event as “the robot detects a wall at the right direction” on the table (Fig. 3.5, upper left). The student can then register the event via a “touch” action on a button.

RoboTable2 then prompts the student to define the robot behavior that corresponds to the event. As shown in Fig. 3.6, the student grasps the robot and moves it forward to define the behavior that corresponds to the event (“if the robot detects a wall at the right direction”). RoboTable2 then adds a description of this behavior in the window (Fig. 3.6, upper left). The student confirms whether this is the intended behavior. The student can perform robot programming by repeatedly registering pairs of events and robot behaviors in an intuitive manner.

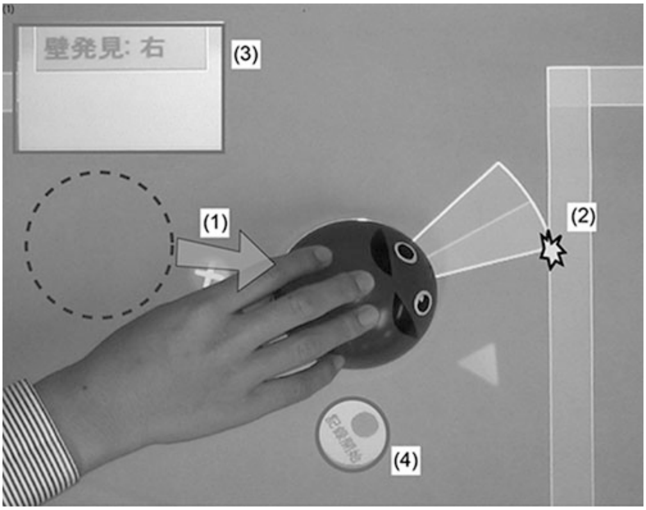

Fig. 3.5 Registration of an event. (*1*) The student grasps and moves the robot until it detects a wall (*2*). (*3*) The detected event is displayed as: "if the robot detects a wall at the right direction." (*4*) If the student finds that this event is appropriate, he/she touches the button displayed near the robot to allow event registration

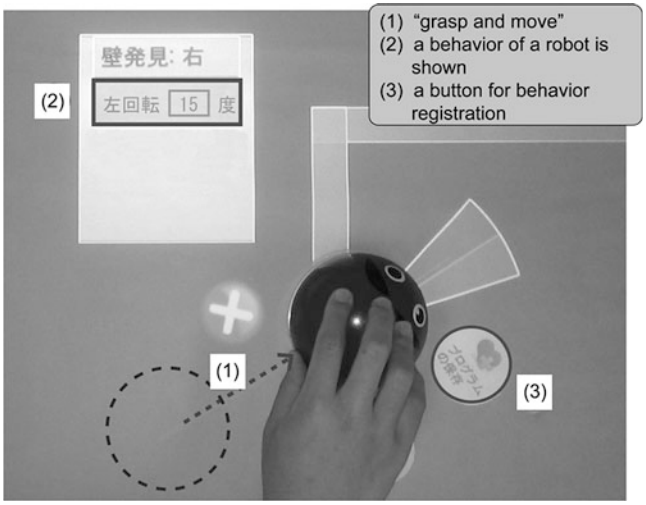

Fig. 3.6 Registration of robot behaviors. (*1*) The student grasps and moves the robot. (*2*) The robot behavior is displayed on the table. (*3*) If the displayed behavior is appropriate, the student touches a button to complete registration

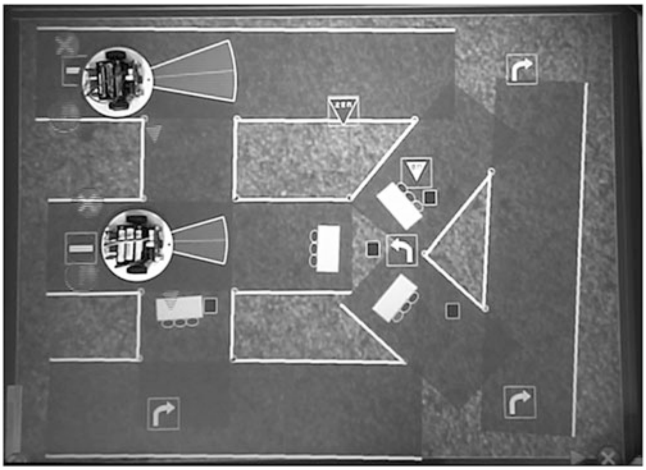

Fig. 3.7 Example of a traffic simulator developed by a student

3.3.2.3 Design of the Physical Contents

A student with little programming experience can create the requisite physical contents for learning. An example of a traffic simulator created using RoboTable2 is shown in Fig. 3.7. The student designed and developed this simulator to demonstrate traffic situations in a downtown area, including complex street junctions.

The student drew the roads with his fingers, before selecting virtual items such as traffic signals and road signs from the pallet shown on the tabletop surface and placing them in various locations on the table. Next, the student defined the behaviors of each robot. To simulate careful and reckless automobile drivers, he made the sensing areas of the robots larger or smaller so the drivers could or could not identify stop signs at various distances. By assigning different lighting times to the red, yellow, and blue lights on each traffic signal, the student controlled the traffic flow in the simulator.

Another example created by a student is the multi-robot hockey game shown in Fig. 3.8. This student conducted robot programming in the same manner as the previous example, and the student created the content in 1 h. These examples confirm that RoboTable2 made it simple for students to design and implement physical content.

3.4 Lessons Learned

Based on educational activities conducted using systems such as those described in this chapter, we confirmed that the key concepts proposed in the previous section could increase the motivational level of students, enhance the student experience,

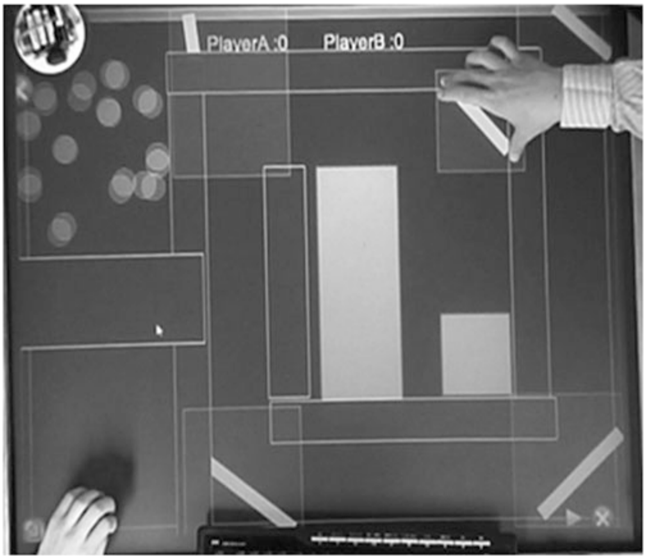

Fig. 3.8 Example of a multi-robot hockey game developed by a student

and support students to facilitate their deeper understanding of subjects (Yamaguchi et al. 2009). The systems also stimulated student discussions and helped students to develop logical or creative solutions to self-identified problems. Some of the issues that need to be investigated in our future research are summarized as follows.

- Design and operation guidelines for learning environments

The learning environments proposed by our group allow stakeholders, including schoolteachers and students, to participate in educational activities in schools, as well as the design and development processes. Much time and effort was invested in constructing these environments. It was often not easy to make all of the arrangements with schoolteachers alone in order to conduct educational activities in schools. Thus, to make these learning environments more readily available to schools, we need to investigate how to reduce the burdens on the stakeholders, especially schoolteachers.

- Appropriate subjects for learning environments that involve interactions with physical items

The curricula are already highly congested in public primary schools in Japan. Children are often expected to learn and understand many subjects within a limited period. However, some subjects might not be suited to the design and development of these types of curricula and systems, which require much time and effort. It is also possible that the proposed environments might not help students to learn in an efficient manner in some areas. Therefore, we need to carefully consider how the proposed learning environments may be applied to different subjects.

- Beyond "wow" effects

In general, students are excited and motivated to use novel learning environments or systems with enhanced technology. This is beneficial because these systems can provide students with learning opportunities. However, it is more important to motivate the students to learn and to be interested in the subjects themselves. Therefore, when we evaluate the proposed learning environments, we will need to analyze what motivates the students and how their level of understanding of subjects changes after using the learning environments.

3.5 Conclusions

In this chapter, we developed technology-enhanced learning environments with connections to the real world, which we evaluated through educational activities in schools. The key concepts related to the design of the environments were defined. The aims of the proposed learning environments are to increase the motivational levels of students during self-directed learning and to enhance their learning experiences. We also considered the lessons learned and the issues that need to be investigated in our future research.

Acknowledgments This work is supported by JSPS Grant-in-Aid for Scientific Research (Grant Number: 25282048).

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Chapter 4
Accessible E-learning for Students with Disabilities: From the Design to the Implementation

Mohamed Jemni, Mohsen Laabidi, and Leila Jemni Ben Ayed

Abstract E-learning systems are now widely adopted. They represent real opportunities for a better quality of education for many people. However, people with disabilities are still encountering many obstacles to benefit from these systems. The main problem, in fact, is that most available e-learning systems are inaccessible to people with disabilities and do not take in consideration their special needs. In this chapter, we present our work toward developing an accessible e-learning system from the design step to the implementation. Our approach is mainly based on the design of accessible e-learning concepts using the model-driven architecture. This approach is validated by the implementation of an accessible e-learning system we called Moodle^{acc+}.

Keywords Accessible e-learning • AccessForAll • Moodle^{acc+} • MDA • ACCUML

4.1 Introduction

Nowadays, e-learning benefits from the fast growth of technologies of information and communication to empower education and to offer very sophisticated educational environments. However, e-learning environments are still far from being accessible for people with disabilities who still meet many barriers to benefit from this learning mode. In fact, the World Health Organization (WHO) estimates that over one billion people are living with some form of disability and facing a wide range of barriers, including access to information, education, and a lack of job opportunities (UNESCO Global Report 2013). And, therefore, access to appropriate

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R. Huang et al. (eds.), *The New Development of Technology Enhanced Learning: Concept, Research and Best Practices*, Lecture Notes in Educational Technology,
DOI 10.1007/978-3-642-38291-8_4, © Springer-Verlag Berlin Heidelberg 2014

ICTs that support learning for students with disabilities is an international policy imperative.

Furthermore, the availability of accessibility guidelines, the diversity of the e-learning platforms, and the evolution of assistive technologies do represent just a partial solution. Actually, some accessibility features may exist in some e-learning environments and applications but implemented in an ad hoc way and exclusively dependent on some specific technologies or targeting only one kind of disability.

In this context, considering accessibility aspects since the design phases of the educational environment and e-learning applications should provide a rational solution. In the work presented in this chapter, we are using model-driven architecture (MDA) for developing an accessible e-learning platform starting from the design step.

This chapter is organized as follows: in the next section, we present basic concepts of accessibility and related aspects, i.e., assistive technologies and accessibility guidelines. Section 4.3 is devoted to present the state of the art of accessible e-learning system as well as its standards and some examples from the literature related to accessible content, accessible e-learning applications, and accessible e-learning environments. In Sect. 4.4, we present our entire approach to develop an accessible e-learning environment from design to implementation, and then we present our prototype of accessible e-learning system that we called Moodle^{acc+} and which is an accessible version of the well-known e-learning platform Moodle. We conclude this chapter by a conclusion and some perspectives.

4.2 E-Accessibility

In this section, we present the different terminologies related to the e-accessibility field such as disability, assistive technology, and Web accessibility.

4.2.1 What Is E-Accessibility?

According to the WHO, electronic accessibility, or e-accessibility, refers to the ease of use of information and communication technologies (ICTs), such as the Internet, by people with disabilities (Web 5). In particular, Web sites need to be developed so that users with disabilities can access the information. For example:

(a) *For people who are blind*, Web sites need to be able to be interpreted by programs which read text aloud and describe any visual images.
(b) *For people who have low vision*, Web pages need adjustable size fonts and sharply contrasting colors.
(c) *For people who are deaf or hard of hearing*, audio content should be accompanied by text versions of the dialogue. Sign language video can also help make audio content more accessible.

4.2.2 What Are Disabilities?

As defined by the WHO, "disabilities" is an umbrella term, covering impairments, activity limitations, and participation restrictions. An impairment is a problem in body function or structure; an activity limitation is a difficulty encountered by an individual in executing a task or action, while a participation restriction is a problem experienced by an individual in involvement in life situations.

4.2.3 Types of Disabilities

Disabilities include various physical and mental impairments that can be summarized in the following list (Web 9):

(a) *Deaf/hard hearing*: Hearing disability includes people that are completely or partially deaf. Deaf people use sign language as a means of communication.
(b) *Brain injuries*: A disability in the brain occurs due to a brain injury.
(c) *Blindness/low vision*: There are hundreds of thousands of people that suffer from minor to various serious vision disability or impairments. These injuries can also result into some serious problems or diseases like blindness and ocular trauma, to name a few. Some of the common vision impairments include scratched cornea, scratches on the sclera, diabetes-related eye conditions, dry eyes, and corneal graft.
(d) *Attention deficit/hyperactivity disorders* (ADHD): ADHD is a common behavioral disorder that affects an estimated 8–10 % of school-age children. Boys are about three times more likely than girls to be diagnosed with it, though it is not yet understood why. Kids with ADHD act without thinking, are hyperactive, and have trouble focusing. They may understand what is expected of them but have trouble following through because they cannot sit still, pay attention, or attend to details.
(e) *Physical disability*: Physical impairment refers to a broad range of disabilities which include orthopedic, neuromuscular, cardiovascular, and pulmonary disorders.
(f) *Psychiatric disability* (affective disorders): Disorders of mood or feeling states either short or long term. Mental health impairment is the term used to describe people who have experienced psychiatric problems or illness such as, personality disorders defined as deeply inadequate patterns of behavior and thought of sufficient severity to cause significant impairment to day-to-day activities.
(g) *Speech and language disability*: When a person is unable to produce speech sounds correctly or fluently or has problems with his or her voice, then he or she has a *speech disorder*. Difficulties pronouncing sounds, or articulation disorders, and stuttering are examples of speech disorders. When a person has trouble understanding others (*receptive language*) or sharing thoughts, ideas,

and feelings completely (*expressive language*), then he or she has a *language disorder*. A stroke can result in aphasia, or a language disorder (Web 7).

(h) *Learning disability*: Called also cognitive disabilities, is a kind of impairment present in people who are suffering from dyslexia and various other learning difficulties and includes speech disorders.

(i) *Medical disability*: Other disabilities include conditions affecting one or more of the body's systems. These include respiratory, immunological, neurological, and circulatory systems such as chronic fatigue syndrome and diabetes.

Furthermore, it is often the case that a student will not have a single disability, but many and some of them may impact on educational needs more than others.

4.2.4 Assistive Technology

Assistive technology is technology used by individuals with disabilities in order to perform functions that might otherwise be difficult or impossible. Assistive technology can include mobility devices such as walkers and wheelchairs, as well as hardware, software, and peripherals that assist people with disabilities in accessing computers or other information technologies. For example, people with limited hand function may use a keyboard with large keys or a special mouse to operate a computer, people who are blind may use software that reads text on the screen in a computer-generated voice, people with low vision may use software that enlarges screen content, people who are deaf may use a TTY (text telephone), or people with speech impairments may use a device that speaks out loud as they enter text via a keyboard.

4.2.5 Advantages

The application of e-accessibility has several advantages for developers and users:

(a) *Technical advantages*

- (i) Reduced site development and maintenance time
- (ii) Reduced server load
- (iii) Improved interoperability
- (iv) Prepared for advanced technologies
- (v) Efficient research

(b) *Financial advantages*

- (i) Search engine optimization
- (ii) Increased Web site use
- (iii) Direct cost savings

(c) *Social advantages*

   (i) Guarantee nondiscrimination
   (ii) Ensure e-inclusion
   (iii) Ensure e-equality

4.2.6 The Web Accessibility Initiative

The World Wide Web Consortium (W3C) (the body responsible for the coordination of developments to Web standards) (Web 11) established the Web Accessibility Initiative (WAI) with a remit to lead the Web to its full potential with a particular reference to promoting a high degree of accessibility for people with disabilities. Many other initiatives, such as Section 508 (Web 6), were established. WAI has successfully raised awareness of the importance of Web accessibility and in developing guidelines which help to ensure that Web resources are accessible.

The WAI gives a set of recommendations including the following:

(a) Web Content Accessibility Guidelines (WCAG)
(b) Authoring Tool Accessibility Guidelines (ATAG)
(c) User Agent Accessibility Guidelines (UAAG)

The WCAG is addressed to Web authors, while the ATAG and UAAG are mainly set to software development communities.

These guidelines are mainly based on the following four principles:

(a) *Perceivable* – Information and user interface components must be presentable to users in ways they can perceive.
(b) *Operable* – User interface components and navigation must be operable.
(c) *Understandable* – Information and the operation of user interface must be understandable.
(d) *Robust* – Content must be robust enough that it can be interpreted reliably by a wide variety of user agents, including assistive technologies.

The WCAG can be compared to a checklist, while the checkpoints are classified in three priority levels based on their impact on the accessibility of Web sites. The compliance of the priority levels results in three conformance levels ("A," "AA," and "AAA") that assess the conformance of each Web page.

Web Content Accessibility Guidelines (WCAG) 2.0 define how to make Web content more accessible to people with disabilities. A conformed Web page to WCAG 2.0 should satisfy the following requirements:

(a) *Level A* – For Level A conformance (the minimum level of conformance), the Web page satisfies all the Level A success criteria, or a conforming alternate version is provided.

(b) *Level AA* – For Level AA conformance, the Web page satisfies all the Level A and Level AA success criteria, or a Level AA conforming alternate version is provided.
(c) *Level AAA* – For Level AAA conformance, the Web page satisfies all the Level A, Level AA, and Level AAA success criteria, or a Level AAA conforming alternate version is provided.

4.3 Accessible E-Learning Systems

The advantages of the online learning have been widely described in the literature (Chorfi and Jemni 2004). The advantages for people with disability are more crucial.

In this section, we present the advantage of e-learning for students with disabilities, the potential barriers to develop accessible e-learning, and some accessible e-learning systems available in the literature.

4.3.1 Definition

In e-learning systems, disability can be defined as a mismatch between the needs and the offered education. Therefore, disability in e-learning is an artifact of the relationship between the learner and the learning environment or education delivery (Laabidi et al. 2014).

Given the reframing of disability above, accessibility can be defined as the ability of the learning environment to adjust the needs of all learners and is determined by the flexibility of the environment.

Demetrios Sampson defines accessible learning systems as "systems that provide accessible learning content through accessible interfaces" (Sampson and Zervas 2008).

4.3.2 Positive Implications of E-Learning for Students with Disabilities

The advantages of the online learning have been widely described in the literature. Thanks to e-learning, the learners can benefit from a personalized education. This personalization may cover the content, the educational environment, and even the learning style and scenarios (Essalmi et al. 2007) in order to fit to the real needs and preferences of the learner (Essalmi et al. 2010). However, most of these works do not address the needs of people with disabilities.

Recently, many publications addressed the issue of accessibility for people with disabilities in using online education environments (Web 8). In this context, we can cite several advantages of e-learning for people with disabilities such as peer support, proactivity, flexibility in time and space, and the impact of the ICT in educational experiences.

Indeed, the Web enables the user to be proactive and self-reliant, rather than reactive and dependent. Furthermore, the flexibility in time and space afforded by distance education modalities allows users to proceed at their own pace.

Multimodal communications allowing students to submit materials electronically, write take-home exams, and contact the professor using e-mail as the primary conduit for teacher-student communication all contributed to increased accessibility for many students with disabilities.

4.3.3 Potential Barriers to Build Accessible E-Learning

Although e-learning has several advantages, there are several obstacles facing students with disabilities to benefit entirely from this mode of education. We present in the following the main obstacles (Klomp 2004):

(a) *Increased development costs/time*: Many authors have written about the increased costs of developing accessible e-learning courses for students with disabilities.
(b) *Lack of awareness* (developers and teachers): The lack of awareness of accessibility issues among course developers and also teachers was identified as a key barrier to accessibility.
(c) *Assistive technology not a catchall*: Assistive technology alone does not remove all access barriers. Some accessibility difficulties are clearly created by the design of courseware and content.
(d) *Luck of adequate evaluation*: Evaluations are developed with non-accessibility in mind. People with disabilities need appropriate evaluation environments taking into consideration constraints of duration, structure, and content presentation.

4.3.4 Standards for Accessible E-Learning Environments

Standards are very important to harmonize the development of accessible e-learning environments. In this context, many initiatives were created. In this section, we present the main standards.

4.3.4.1 DAISY Standard (Digital Accessible Information System)

The DAISY standard is an XML standard for accessible electronic books that has been designed in such a way that books can be read by persons with print disabilities, including the blind and the visually impaired, but also by people with dyslexia or motor impairments. A DAISY book (Burger et al. 2012) is composed of a set of digital files that may include the following:

- Digital audio files containing a human narration of part of all of the source text
- A marked-up file containing some or all of the text
- A synchronization file to relate markings in the text file with time points in the audio file
- A navigation control file which enables the user to move smoothly between file while synchronization between text and audio is maintained

Books can be read on refreshable Braille displays or listened to on audio devices. Books can be searched, bookmarked, and navigated through structure elements such as titles, footnotes, etc. The DAISY became an ANSI/ISO standard in March 2002.

4.3.4.2 The IMS AccessForAll and the ISO Accessibility Standards

According to the IMS Global Learning Consortium (Web 4), accessibility is determined by the flexibility of the education environment (with respect to presentation, control methods, access modality, and learner supports) and the availability of adequate alternative-but-equivalent content and activities.

Within its accessibility project, IMS developed various specifications and guidelines serving this purpose, focusing on adaptation or personalization of resources, interfaces, and content to meet the needs of individuals.

Among these specifications, we encounter the IMS AccessForAll, which is designed to define and describe resource accessibility. Its goal is to provide a means whereby resources are matched to the individual accessibility needs and preferences of a particular person.

More recently, a new standard has peeped out in the accessibility scene: the ISO FDIS 24751 accessibility standards.

Both of IMS and ISO specifications are based on the learners' profiling and on the description of the didactical materials through metadata (Fig. 4.1). The framework is divided into the following concepts, which, when used in conjunction, make possible the meeting of resources to the needs and preferences and the description of resource accessibility:

(a) A statement of the needs and preferences of the individual user, at the time and in the context they are in (AccessForAll personal needs and preferences profile – PNP): it defines three elements that represent learner preferences:

  - *Display* defines how the interface and content should be presented to the learner. It covers speech synthesizers (e.g., screen readers), screen

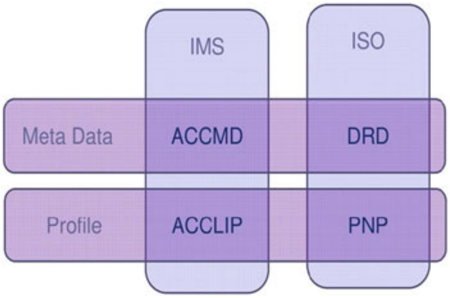


Fig. 4.1 IMS AccessForAll and ISO specifications

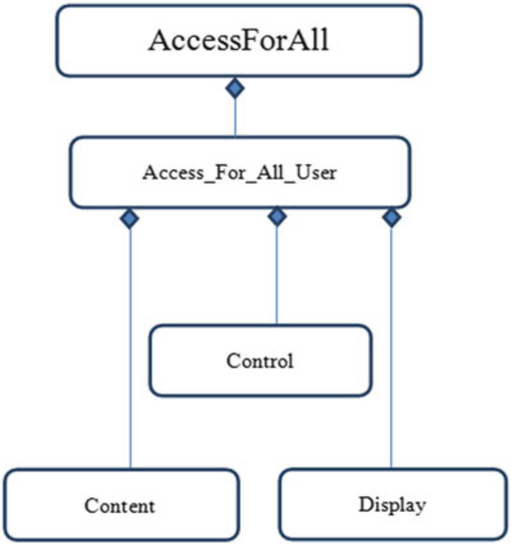


Fig. 4.2 AccessForAll PNP information model

enhancement (e.g., screen magnifiers), text highlighting, Braille settings, tactile displays, visual alternatives to audio alerts, and content structure.

- *Control* defines alternative ways of controlling the technology. It covers accessibility enhancements for a standard keyboard, virtual keyboards, alternative keyboards, mouse emulators, alternative pointing devices, voice recognition settings, and navigation through content.
- *Content* defines content preferences, such as alternatives to visual content (e.g., audio descriptions), alternatives to text (e.g., graphics), alternatives to audio content (e.g., captions), links to personal style sheets, and requests for extra time (Fig. 4.2).

(b) A statement of the relevant characteristics of a resource to be matched to the PNP (AccessForAll digital resource description DRD) which assumes two categories of resources: original and adapted. An original resource is the initial or default resource. An adaptation contains the same intellectual content as the original resource but in a different form such as in a different sensory mode, or with more or less dense semantics (Fig. 4.3).

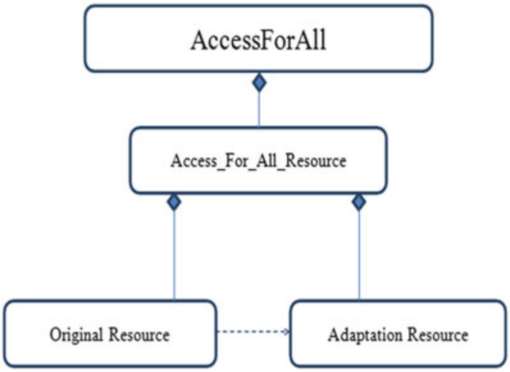


Fig. 4.3 AccessForAll DRD information model

4.3.4.3 Example of AccessForAll Use

The following example shows the use of AccessForAll for a visual impairment or a low vision learner. The learner has a personal needs and preferences (PNP) profile that defines his/her preferences relating to vision requirements. In this profile, we suppose that the learner identifies a need for alternatives to visual content. The learner requests audio descriptions and long descriptions as his/her preferred adaptation methods for visual content.

To accommodate this learner, the original resource, which is an image, needs to be replaced by an adaptation. When the learner requests to view a course containing the original image, the system recognizes that the learner requires alternatives, discovers that a resource with the appropriate characteristics exists, and is able to substitute the original with a long description for the image.

To properly replace the original resource with an appropriate alternative for the learner, metadata describing the learner's preferences and both the original and adapted resource needs to be correctly defined. Based on the learners' preferences for textual adaptations to visual content, the following metadata might be included in their personal needs and preferences (PNP) file:

```
accessModeRequired.existingAccessMode = visual
accessModeRequired.adaptationRequested = textual

adaptationTypeRequired.existingAccessMode = visual
adaptationTypeRequired.adaptationRequested =
audioDescription

adaptationTypeRequired.existingAccessMode = visual
adaptationTypeRequired.adaptationRequested =
longDescription
```

When the learner accesses the course, the system will check the learner's profile and discover that he requires alternatives to visual content. It will then check the resource the learner is requesting (the original image) to check if it is a visual attribute. As this resource is visual, the system will look for alternatives that match the learner's preferences using metadata description. The metadata generated by the adaptation process is given below:

```
accessMode = textOnImage
hasAdaptation = someAdaptationSet
isAdaptationOf = someObjectSet
accessMode = textual
accessModeAdapted = textOnImage
adaptationType = longDescription
```

4.3.5 Presentation of Some Accessible E-Learning Solutions

Since the early 1990s, the online training offer has grown dramatically. However, this trend is not yet similar for people with disabilities with the exception of a few experiments that constitute the beginning of a work still far from being up to the expected results.

(a) *Development of accessible content*: We give below some related works from the literature.

- Arrigo (2009) has developed a tool to help teachers to implement the e-learning content available to visually impaired people and that by integration of visual interfaces using voice synthesis. Such technic allows learners to use the tools of synchronous and asynchronous communication, access the Web, and find the right information. This work is based on the W3C's WAI (Web Accessibility Initiative) recommendations and, in particular, the Web Content Accessibility Guidelines (WCAG).
- ANGEL (Web 1) is a commercial Course Management System (CMS) which adapts user interfaces to AccLIP settings. It imports a content package with AccMD metadata and assigning appropriate resources to learners.
- The *Websign* (El Ghoul and Jemni 2009b) team of the Research Laboratory of Technologies of Information and Communication and Electrical Engineering (LaTICE) (Web 10) has developed an interface for learning and teaching sign language. The application produces multimedia content including an avatar for sign language interpretation (Jemni et al. 2007).
- The accessible *C2i* courses: In Tunisia, the Virtual University of Tunis (Web 12), in collaboration with the Research Laboratory LaTICE, launched a pilot project for ICT education of students with disabilities (Jemni and Laabidi 2008). It consists on producing accessible content for six courses providing

basic knowledge for learning computer and Internet use. No consideration has been given to management platforms learning. This work is based on the WCAG and the courses have the AAA accessibility level.

(b) *The development of accessible e-learning applications*: Since the publication of the notice of disability and special educational needs, several approaches to design electronic educational resources have been developed. These approaches are mainly based on a purely technological context; the educational aspect is completely ignored.

For instance, similar to screen reader technology that allows blind and people with reading difficulties to use computer and to access to the digital information, El Ghoul and Jemni (2009a) developed a novel screen reader dedicated to deaf people based on avatar technology and real-time sign language machine translation.

On the other hand, in recent years, several approaches have been used in order to develop dynamic Web applications based on a model-driven architecture (Karampiperis and Sampson 2005). We cite, as an example, Dante (Renaux and Le Pallec 2005) which is based on OOWS (Object-Oriented Web Solutions) method approach and WSDM (Web Site Design Method). It supports technologies for the visually impaired as well as additional information on navigation.

Furthermore, Web-4-All is an application developed for Industry Canada to ensure that seniors, new Canadians, and people with disabilities or literacy challenges have computer access to services and information on the Internet. With Web-4-All, each user can select, save, and deploy his own interface preferences using personal smart card technology that automatically configures a suite of assistive software and hardware (Web 3).

(c) *The development of accessible e-learning environments*: Several studies have focused on the accessibility of a particular kind of disabilities. Indeed, some works have been done with the aim of ensuring accessibility for blind people to e-learning. It is to implement a system of learning management LMS (Gabrielli et al. 2005); two aspects have been considered: technology and methodology.

From a technological point of view, the system produces document summaries for quick and easy understanding of the text by blind people when they use voice interfaces. However, this solution is unusable without a screen reader and it is absurd for users with different disabilities.

From a methodological point of view, it is necessary to enrich the document, originally designed for visual interfaces, by information promoting adequate education for the blind.

Other researchers have been interested in the development process of editing interface design to help authors to create accessible content.

In BeLearning (Vieritz et al. 2007) at the Technical University of Berlin (funded by the European Social Fund ESF), a project-based development model is designed to improve the accessibility criteria of e-learning platforms.

The approach used in this project is based on the semantic annotation of content. It saves all the information necessary to present the content in the most appropriate format for its accessibility. This semantic annotation also extends to relationships and the meaning of the used objects.

TILE (The Inclusive Learning Exchange) is an e-learning environment that enables learner-centric transformation of learning content and delivery authoring support for transformable content and for metadata browser. TILE is a learning object repository that supports customization of the learning content to the individual needs of each learner (Web 2).

4.4 The Accessible E-Learning System Moodle^{acc+}

4.4.1 The Architecture of Our Accessible E-Learning System

As presented in the following figure, an accessible e-learning system consists of three elements: learner accessibility, accessible contents, and accessible applications.

In this context, the accessibility preferences of learners defined by the IMS standard, and through AccessForAll project, play a vital role. Everything should work so that the learner is well served by applications that make accessible the available educational content (Fig. 4.4).

First, the system offers to authors authoring tools that take into account the recommendations of accessibility defined by the initiative of the W3C's WAI.

Second, the system describes the content developed in the first stage by means of accessibility metadata as defined by the standard IMS AccMD. Once the educational

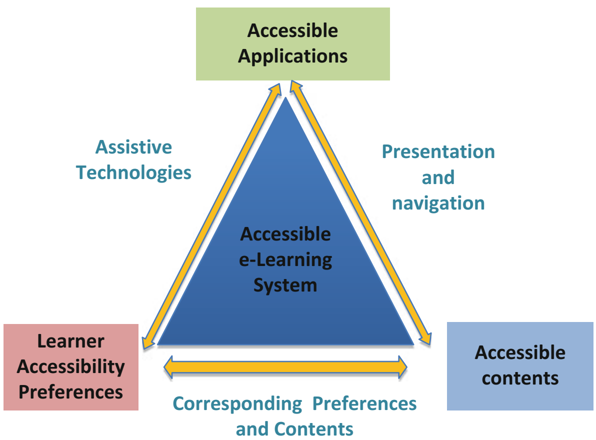


Fig. 4.4 Architecture of an accessible e-learning system

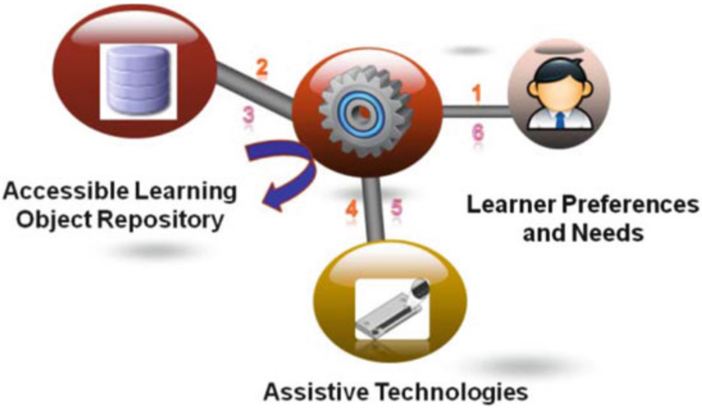


Fig. 4.5 Personalizing an accessible e-learning system

content is available and described by metadata accessibility, teachers are called upon to define the learning processes that exploit the available content and, at the same time, respect the accessibility preferences of learners (Laabidi and Jemni 2010) (Fig. 4.5).

The learner will be able to introduce these preferences in the system to be used during the process of adaptation.

4.4.2 The Design of an Accessible E-Learning System

Unlike existent systems based on an ad hoc accessibility implementation, we are considering accessibility from an early stage of systems life cycle. The OMG Model-Driven Architecture (MDA) turns out the most appropriate (Jeschke and Vieritz 2007).

MDA is an approach for application specification and interoperability (Nodenot 2004). MDA is mainly based on the separation of concerns between domain knowledge and platform specificities. It relies on the use of MOF (Meta Object Facility) metamodels and UML (Unified Modeling Language) models for every step of the application life cycle.

This approach depends on the definition of the following:

(a) A specification model called Computational-Independent Model or CIM
(b) A conception model called Platform-Independent Model or PIM
(c) An implementation model called Platform-Specific Model or PSM
(d) A set of model transformations (also called mappings).

At the first level, the system requirements are modeled in a Computation-Independent Model (CIM) that defines the system within an operating environment.

At the next level, there is the Platform-Independent Model (PIM). A PIM describes the system functionalities, but without considering details about where and how the system is going to be implemented. The aim of the following step is to transform the PIM into a target Platform-Specific Model (PSM). The most important advantage of this approach is that it allows software engineers to define automatic transformations from PIMs to PSMs (Bizonova et al. 2007; Abdallah et al. 2008).

4.4.2.1 The Profile-Based Accessible E-Learning Formalism (PBAE)

The aim of this PBAE formalism (Laabidi and Jemni 2009) is to define a modeling language for the development process of accessible e-learning systems. This formalism is based on the definition of the field profile, the technical definitions, the operational part, and an illustrative example.

We recall that a profile is a set of extension of UML to adapt to a particular domain mechanism (Vallecillo–Moreno and Fuentes-Fernandez 2004).

In our case, the profile consists on the definition of stereotypes and constraints based on the accessibility guidelines defined by the WAI.

These profiles can be used in different design stages such as specification and system modeling.

The constraints can be used to describe some elements of the model such as the description of textual alternatives of visual information. For example:

```
Context image
If alt<=60
Then longdesc -> isEmpty()
Else longdesc -> notEmpty()
Endif
```

4.4.2.2 The ACCUML Metamodel

In this section, we present our new UML metamodel called “ACCUML” (Hebiri et al. 2010) for modeling digital accessibility in e-learning systems. The application of the MDA approach passes certainly through the establishment of basic foundations for modeling accessibility.

ACCUML consists on the creation of two new meta-classes for the control and the display of systems uses cases according to the access for all specifications (Fig. 4.6).

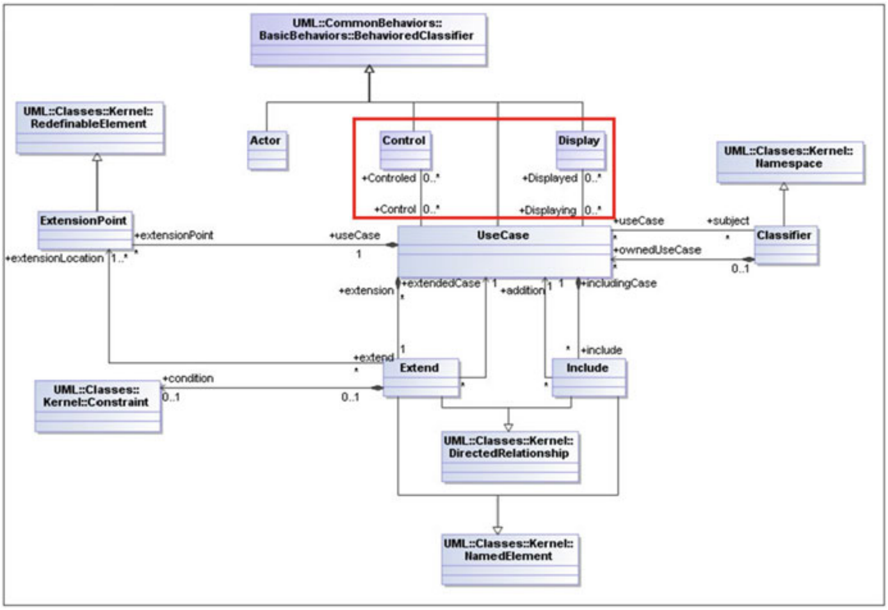


Fig. 4.6 The ACCUML metamodel

This work is concretized through the development of a new computer-based software engineering called ArgoUML^{acc+} (Laabidi and Jemni 2010).

4.4.3 Integration of Accessibility in E-Learning Systems: Case of Moodle^{acc+}

With ArgoUML^{acc+}, we can create Platform-Independent Models (PIMs). After this step, the integration of the obtained models in the e-learning systems is needed. This integration requires some transformations of the PIM in order to obtain Platform-Specific Models (PSMs) and also the extension of the PHP metamodel.

To make these transformations feasible, we have enriched the PHP metamodel with a new php class called "resource." In this order, we have established a set of transformation rules to integrate the generated models directly into the Moodle platform. As result, all accessibilities properties are implemented on the platform and are ready to administrator settings.

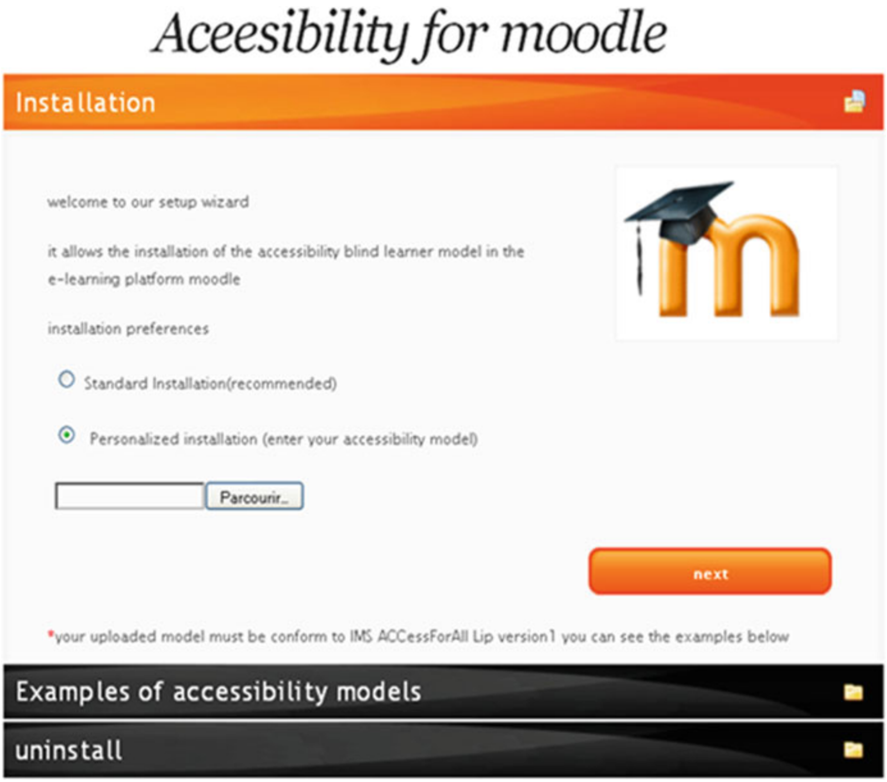


Fig. 4.7 Moodle^{acc+} installation

4.4.4 The Accessible E-Learning Platform Moodle^{acc+}

We present in this section some functions of our accessible e-learning platform Moodle^{acc+}.

Moodle^{acc+} allows users to:

(a) Evaluate accessibility
(b) Develop accessible e-learning content
(c) Assist learner to set his needs and preferences
(d) Assist tutor to deliver accessible e-learning content

It's very easy for a novice user to install the accessibility module on a standard Moodle platform. As specified in the next figure, the user has just to choose an existent model of accessibility or to import a model from another existing platform (Laabidi and Jemni 2010) (Fig. 4.7).

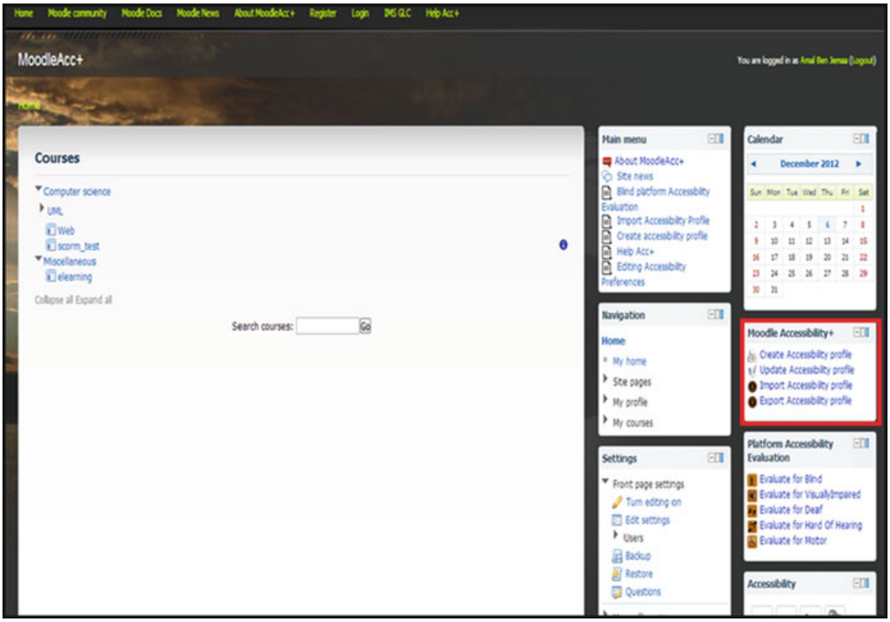


Fig. 4.8 Integrated Moodle^{acc+} interfaces

At any time, the user can:

(a) Create a new profile of accessibility
(b) Update in existing profile of accessibility
(c) Import and export profiles of accessibility (Fig. 4.8)

According to IMS AccessForAll standard, Moodle^{acc+} allows tutors or course editors to specify accessibility metadata in order to much the adapted content to the appropriate learner (Fig. 4.9).

For example, Fig. 4.10 presents an example of content adapted to a visually impaired learner. In this case, Moodle^{acc+}, knowing that the learner is blind, replaces an image by an accessible text through a screen reader (Ben Brahim et al. 2013).

4.5 Conclusion

In this chapter, we have presented an overview of accessibility, assistive technology, and accessible educational environment. Then we presented our approach for developing an accessible e-learning system from the design to the implementation. We used mainly MDA approach for the design phase to take in consideration in an earlier step all accessibility aspects.

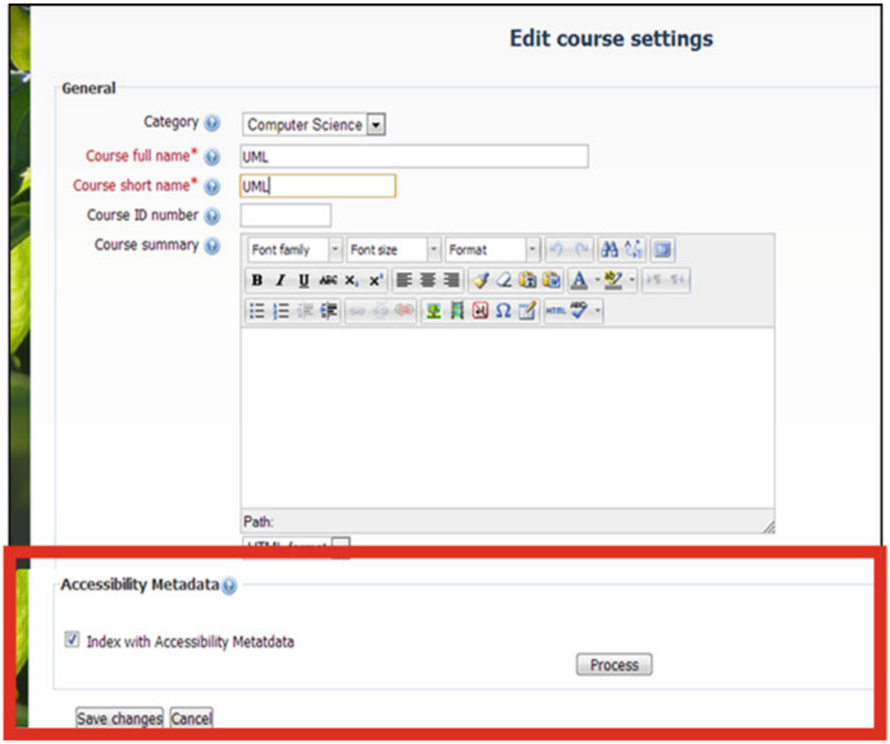
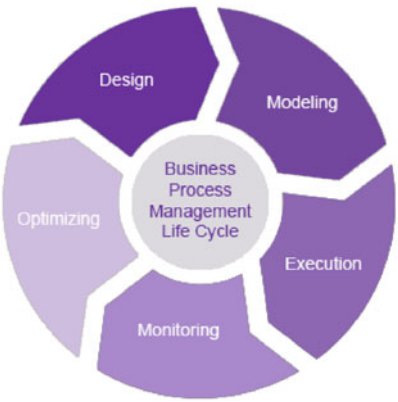


Fig. 4.9 Accessibility metadata with Moodle^{acc+}



The textual alternative of this image is described as follows:
The picture represents a diagram of a business process management life cycle.
This life cycle is composed of five steps:
Design, Modeling, Execution, Monitoring and Optimizing.

(This text is read by a screen reader).

Fig. 4.10 Moodle^{acc+} adapted content for visually impaired people

Finally, we presented our accessible e-learning system prototype Moodle^{acc+}, which is in fact an accessible version of the platform Moodle.

As perspective of this work, we are planning to extend our system by setting up an automatic model transformation approach and expanding fields of applications on different e-learning platforms including mobile learning.

Acknowledgments The authors would like to thank the Tunisian Association of E-Accessibility (www.e-access.tn) for supporting this work.

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Chapter 5
A Systematic Analysis of Metadata Application Profiles of Learning Object Repositories in Europe

Panagiotis Zervas, Alexandros Kalamatianos, and Demetrios G. Sampson

Abstract Over the past years, several initiatives have emerged worldwide towards the provision of open access to educational resources, in the form of learning objects (LOs). The main objective of such initiatives is to support the process of organizing, classifying, and storing LOs and their associated metadata in Web-based repositories which are called learning object repositories (LORs). Within this framework, popular ways for describing LOs are the Dublin Core Metadata Element Set (DCMES) and the IEEE Learning Object Metadata (LOM) Standard. However, it has been recognized that it is not possible for generic standards such as DCMES and IEEE LOM to be used to fully meet community and context-specific users' needs. This has lead to the emergence of the metadata application profile (AP) concept and a number of metadata APs have been developed, which are used by a variety of LORs that are currently operating online. On the other hand, with many LORs implemented based on different metadata APs, the issue of metadata interoperability between these LORs is crucial. In this chapter, we focus on metadata interoperability of different LORs that have been developed by institutions, communities, or consortiums in Europe. More specifically, we present the results of a systematic analysis of metadata APs used in nineteen (19) European LORs, and we provide recommendations for future development of metadata APs.

Keywords Learning object • Learning object repository • Application profile • Metadata • Interoperability • Analysis

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R. Huang et al. (eds.), *The New Development of Technology Enhanced Learning: Concept, Research and Best Practices*, Lecture Notes in Educational Technology, DOI 10.1007/978-3-642-38291-8_5,

5.1 Introduction

Over the past years, several initiatives have emerged worldwide towards the provision of open access to educational resources, in the form of learning objects (LOs) such as "video and audio lectures (podcasts), references and readings, workbooks and textbooks, multimedia animations, simulations, experiments and demonstrations, as well as teachers' guides and lesson plans" (McGreal 2008). UNESCO (2002) has defined Open Educational Resources (OERs) as the "technology-enabled, open provision of educational resources for consultation, use and adaptation by a community of users for non-commercial purposes." The Open Educational Resources initiative is defined as "a technology-empowered initiative that aims to create and share educational resources that are freely available online for everyone at a global level" (Caswell et al. 2008). The main aim of such initiatives is to support the process of organizing, classifying, and storing LOs and their associated metadata in Web-based repositories which are called learning object repositories (LORs) (McGreal 2004). As a result, a variety of LORs are currently operating online, facilitating end users (namely, students and teachers) to have access to numerous collections of LOs (Ehlers 2011). An important factor, in order to enable access to these LOs, is the existence of educational metadata associated with these LOs. For this purpose, different metadata standards have emerged such as the IEEE Learning Object Metadata (IEEE LOM) Standard (IEEE LTSC 2005) and the Dublin Core Metadata Element Set (DCMES) (Dublin Core 2004). However, it is not possible for generic standards to fully meet community and context-specific users' needs (Duval et al. 2002). This has lead to the emergence of the metadata application profile (AP) concept and a number of metadata APs have been developed, which are used by a rich variety of LORs that are currently in operation (Mason and Ellis 2009; Currier 2008; Mason and Galatis 2007).

On the other hand, with many LORs implemented based on different metadata APs, the issue of metadata interoperability between these LORs is crucial. Interoperability in the context of metadata refers to the ability of a system to process metadata records produced by a third-party system (Smith et al. 2006). This metadata exchange enables users in each LOR to extend their access beyond locally available LOs to a variety of LOs collected in other LORs, by using compatible tools and services (e.g., federated search) (Najjar 2008). Within this context, in this chapter, we focus on metadata interoperability of different LORs that have been developed by institutions, communities, or consortiums in Europe. More specifically, we present the results of a systematic analysis of metadata APs used in nineteen (19) European LORs, and we provide recommendations for future development of metadata APs.

This chapter is structured as follows. Following this introduction, Sect. 5.2 provides background information for the basic terms that are used in this book chapter. In Sect. 5.3, the methodology of this study is presented describing the guidelines for building metadata application profiles, as well as the steps that will be followed within this particular analysis. Section 5.4 presents the analysis results from a sample of existing metadata application profiles used by European LORs. Section 5.5 identifies a number of outcomes and recommendations. Finally, main conclusions and ideas for future work are discussed.

5.2 Background

Learning objects (LOs) are a common format for developing and sharing educational content, and they have been defined by Wiley (2002) as "any type of digital resource that can be reused to support learning." LOs and their associated metadata are typically organized, classified, and stored in Web-based repositories which are referred to as learning object repositories (LORs). McGreal (2004) has defined LORs as systems that "enable users to locate, evaluate and manage learning objects through the use of "metadata," namely, descriptors or tags that systematically describe many aspects of a given learning object, from its technical to its pedagogical characteristics."

Metadata are generally defined as "data about an information resource, or simply data about data" (Berners-Lee 1997). Metadata describe the different characteristics and attributes of an information source, e.g., the title, the author, the date, and the subject. They are made up of data items that are associated with the information sources, which are called metadata elements. Metadata models are structured sets of metadata elements designed for a specific purpose, such as describing a particular type of information source (NISO 2004). Metadata specifications are well-defined and widely agreed metadata models usually developed and promoted by individual organizations or consortia of partners from industry or academia. When a specification is widely recognized and adopted by some standardization organization, it then becomes a metadata standard. Widely adopted metadata standards include the following: (a) the Dublin Core Metadata Element Set (DCMES) (Dublin Core 2004), which is a standard for describing general information resources available online, and (b) the IEEE Learning Object Metadata (IEEE LOM) (IEEE LTSC 2005), which is a standard particularly developed for describing LOs.

Despite the existence of widely accepted metadata standards, it has been identified that it is not possible for generic standards (such as IEEE LOM and DCMES) to fully meet specific requirements and thoroughly accommodate the particular needs of different educational communities requiring local extensions or modifications to these standards (Duval et al. 2002). As a result, a common practice of generating metadata application profiles (APs) has emerged as a means of addressing this problem (Mason and Ellis 2009; Currier 2008; Mason and Galatis 2007). The Workshop on Learning Technologies (WS-LT) of the European Committee for Standardization (CEN/ISSS) (Smith et al. 2006) defines a metadata application profile (AP) as: "an assemblage of metadata elements selected from one or more metadata schemas and combined in a compound schema. Application profiles provide the means to express principles of modularity and extensibility. The purpose of a metadata application profile is to adapt or combine existing schemas into a package that is tailored to the functional requirements of a particular application, while retaining interoperability with the original base schemas."

When a LOR is developed, an initial step includes the definition of the metadata schema that will be used for characterizing the LOs to be stored in this LOR. Many of the existing LORs that have been developed worldwide adopt IEEE LOM or DCMES or a metadata AP of these standards for describing their LOs, aiming to facilitate their metadata interoperability with other LORs (McGreal 2008). Although there are several works in the literature that review the deployment and the implementation of existing LORs (Ochoa and Duval 2009; EdReNe 2008; Tzikopoulos et al. 2007), there has not been a systematic analysis and comparison of the way metadata APs are implemented in LORs with a particular geographical coverage such as European LORs. To this end, this chapter particularly focuses on metadata implementations in European LORs.

5.3 Methodology

5.3.1 Guidelines for Developing Metadata Application Profiles

Metadata APs consist of metadata elements selected by one or more base metadata schemas and they apply additional restrictions to these elements (Heery and Patel 2000). For instance, they limit the options available to a subset of those available in the original schemas. Nevertheless, it is important in the process of metadata application profiling, to support interested parties, who are interesting in developing APs, with a consistent practice that will facilitate them in this process. For this purpose, international organizations such as IMS GLC and the European Committee for Standardization (CEN/ISSS) have published guidelines for the development of APs with specific focus on the IEEE LOM standard. These guidelines include the following steps (Smith et al. 2006; 2IMS GLC 2005):

- *Step 1 – Selection of data elements*: During this step the data elements that the new metadata AP will be built on are selected.
- *Step 2 – Size and smallest permitted maximum*: This step includes the definition of the size that a data element is allowed to have at a metadata instance. More specifically, the size can be equal to one (when the data element are allowed only one value at the metadata instance) or more than one (when the data element are allowed multiple values at the metadata instance). In the second case, a smallest permitted maximum is defined, which is the smallest number of occurrences of a data element in a metadata instance. However, it should be noted that the new AP can reduce the size of a data element or keep it equal to the value of the base standard but it cannot increase the size of a data element.
- *Step 3 – Data elements from multiple namespaces*: This step aims at the definition of data elements from different namespaces, which are part of different metadata schemas.

- *Step 4 – Adding local data elements*: During this step new local data elements, which are not contained to the initial metadata schema, are added to the new metadata AP.
- *Step 5 – Obligation of data elements*: This step aims at the definition of the mandatory (i.e., the value for these data elements shall always be present), the conditional (i.e., the value for the data element shall be present only if a certain condition is satisfied), and the recommended data elements (some metadata APs recommend including values for specific metadata elements).
- *Step 6 – Value space*: During this step the value space of the data elements is defined. The value space defines the set of values that the data element shall derive its value from. The metadata AP may be more restrictive about the value space of a data element than the base standard but it cannot be less restrictive.
- *Step 7 – Relationship and dependency*: This step includes the definition of interrelationships and dependencies between data elements. The metadata AP may be more restrictive about such interrelationships than the base standard but it cannot be less restrictive.
- *Step 8 – Data type profiling*: This step aims at data type profiling of the metadata elements of the new AP. Therefore, all the rules defined above for metadata APs can also be applicable to data types.
- *Step 9 – Application profile binding*: The final step includes the production of the AP binding, which is the conceptual data schema of the AP and should be represented in XML schema or RDF format.

These guidelines for developing metadata APs could be used for analyzing the metadata APs used in European LORs, as we present in the following sections.

5.3.2 Method of Analysis

5.3.2.1 Sample

A number of metadata APs from operating European LORs have been examined, in order to identify the metadata that they are using. The examination sample of the metadata APs was selected by considering the list provided by Open Discovery Space Project (http://opendiscoveryspace.eu/repositories), which is a major European initiative aiming to build a federated infrastructure for a super-repository on top of these LORs. Table 5.1 provides an overview of the European LORs for which their metadata APs were analyzed.

Overall, the analysis included nineteen (19) LORs. From these LORs, sixteen (16) are using IEEE LOM compatible metadata and three (3) are using DCMES compatible metadata. Moreover, twelve (12) of them have a European coverage, whereas seven (7) of them have national coverage targeting four (4) different European countries, namely, Greece, Austria, Bulgaria, and Croatia. The total

Table 5.1 Overview of European LORs

No.	Name	URL	Coverage	Metadata AP is based on	# LOs[a]
1.	Open Science Resources Repository (OSR)	http://www.osrportal.eu	European	IEEE LOM	1,862
2.	Photodentro/Digital School LOR	http://photodentro.edu.gr	National (Greece)	IEEE LOM	6,340
3.	Photodentro/Educational Video Repository	http://photodentro.edu.gr/video	National (Greece)	IEEE LOM	679
4.	Discover the COSMOS	http://portal.discoverthecosmos.eu	European	IEEE LOM	81,000
5.	I2G Intergeo	http://i2geo.net	European	IEEE LOM	3,635
6.	Dryades	http://www.dryades.eu	European	DCMES	200,465
7.	LMS.at	https://lms.at	National (Austria)	IEEE LOM	13,224
8.	Bildungspool	http://bildungspool.bildung.at	National (Austria)	IEEE LOM	385
9.	SIVECO LRE Repository	http://www.siveco.ro/en	European	IEEE LOM	794
10.	Znam.bg	http://znam.bg	National (Bulgaria)	DCMES	96,000
11.	Bulgarian National Educational Repository	http://resursi.e-edu.bg	National (Bulgaria)	DCMES	1,050
12.	Moodle for CARNet's Users	http://moodle.carnet.hr	National (Croatia)	IEEE LOM	44,000
13.	OpenScout	http://learn.openscout.net/search.html	European	IEEE LOM	52,958
14.	LaProf	http://www.language-learning-portal.eu	European	IEEE LOM	753
15.	Organic.Edunet	http://portal.organic-edunet.eu/	European	IEEE LOM	12,360
16.	Rural Observatory	http://www.rural-observatory.eu	European	IEEE LOM	409
17.	LAFLOR	http://laflor.laclo.org	European	IEEE LOM	51,000
18.	Metadata for Architectural Contents in Europe (MACE)	http://portal.mace-project.eu	European	IEEE LOM	200,000
19.	Learning Resource Exchange (LRE)	http://lreforschools.eun.org	European	IEEE LOM	185,940
Total number of LOs					**952,854**

[a]Data retrieved on November 9, 2012

number of LOs included in these LORs is around one million, which constitutes a major sample for our study.

5.3.2.2 Process

For each LOR presented in Table 5.1, the metadata APs that they are using were mapped against the IEEE LOM metadata elements. For those LORs that are using metadata APs based on DCMES, a mapping proposed by the IEEE LOM standard (IEEE LTSC 2005) was adopted. Next, for each metadata AP we studied the modifications that have been performed by the developer of the metadata AP. These modifications were studied in accordance with the guidelines presented in Sect. 5.3.1. However, it was not possible to identify possible modifications for all guidelines presented in Sect. 5.3.1 due to insufficient documentation for some of the examined metadata APs. On the other hand, it was possible to study the modifications for all metadata APs for a subsample of the guidelines presented in Sect. 5.3.1. These guidelines were identified as dimensions for our analysis and included the following: (a) appearance of metadata elements (step 1), (b) obligation status of metadata elements (step 5), and (c) value space of metadata elements (step 6).

5.4 Analysis of Metadata Application Profiles Used in European Learning Object Repositories

5.4.1 Appearance

The number of times that a LOM metadata element appears in the examined metadata APs has been counted. Figure 5.1 gives an overview of the percentage of appearance of elements. The presentation of elements follows the IEEE LOM categories but the elements in each category (mentioned with a different color) have been sorted based on their appearance to the examined metadata APs.

As Fig. 5.1 depicts, all IEEE LOM metadata elements appear at least once in all examined metadata APs. Moreover, all metadata APs are using an element to store the identifier of the LO. In some cases, this is only a URL (in other cases, a formal catalog system can also be used). This identifier is captured by the element "1.1.2 Entry" (inferior element of 1.1 Identifier). Additionally, all metadata APs are using an element to capture the title of the LO. This title is captured by the element "1.2 Title" of the general category. On the other hand, the element "4.5 Installation.Remarks" of the technical category is the least used element in the examined metadata APs. Additionally, if we consider the elements that appear in more than 75 % of the examined metadata APs, then we can notice the following regarding the individual categories of the IEEE LOM standard:

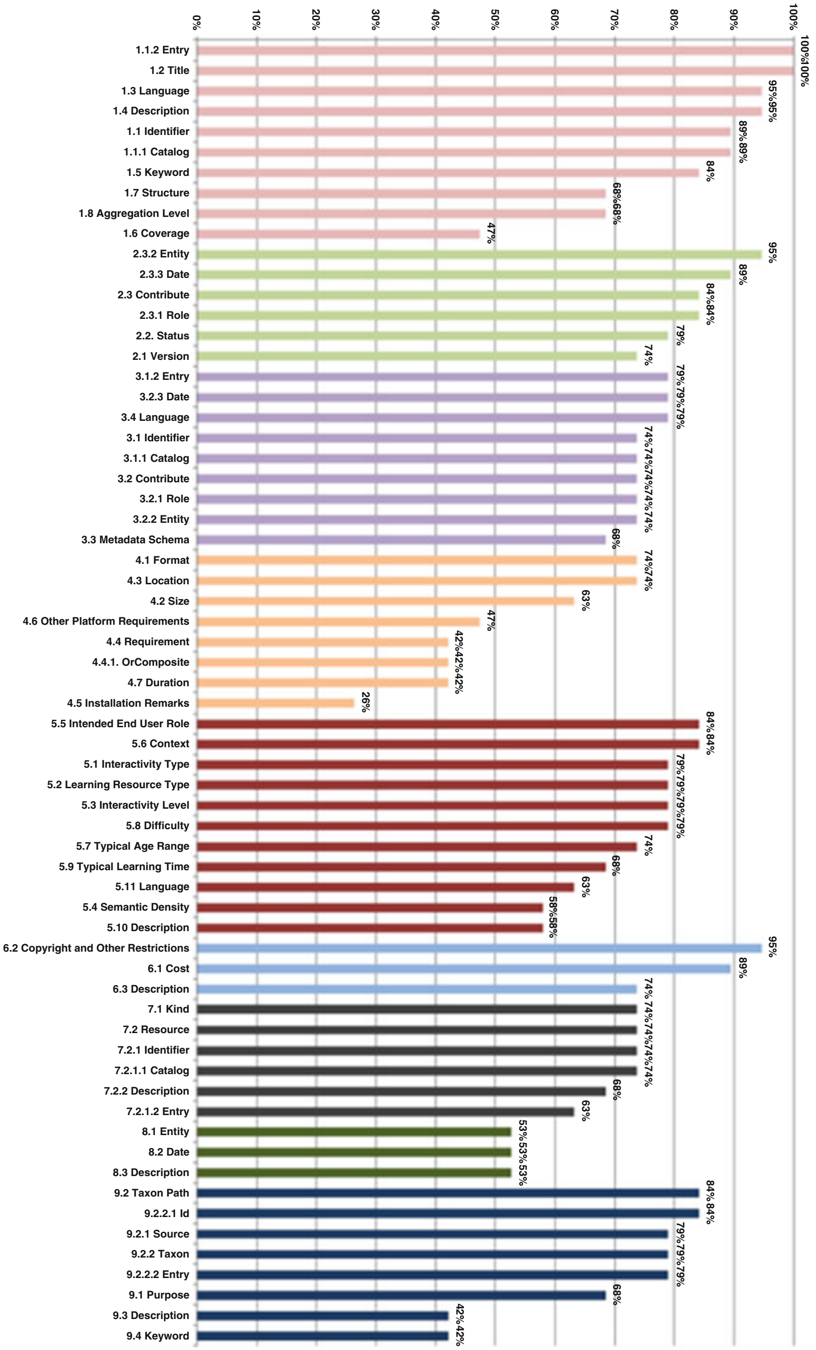

Fig. 5.1 IEEE LOM elements percentage of appearance in examined metadata APs

- *General category*: As far as the general characteristics of the LO are concerned, the following information is usually captured – (a) identifier (100 %), (b) title (100 %), (c) language (95 %), (d) description (95 %), and (e) keyword (84 %).
- *Life cycle category*: As far as the life cycle of the LO is concerned, the following information is usually captured – (a) information about the entities that have contribute to the LO (95 %), (b) role of the entities that have contributed to the LO (84 %), and (c) status of the LO (79 %).
- *Meta-metadata category*: As far as the meta-metadata of the LO is concerned, the following information is usually captured: (a) information about the entities that have contribute to the metadata of LO (79 %) and (b) the language of the LO metadata record (79 %).
- *Technical category*: As far as the technical characteristics of the LO are concerned, all metadata elements of this category are below the threshold of 75 %; thus, we cannot identify any usually captured information.
- *Educational category*: As far as the educational characteristics of the LO are concerned, the following information is usually captured: (a) intended end user role (84 %), (b) educational context/level (84 %), (c) type of the interactivity of the LO (79 %), (d) type of the LO (79 %), (e) interactivity level (79 %), and (f) difficulty of the LO (79 %).
- *Rights*: As far as the copyrights of the LO are concerned, the following information is usually captured: (a) copyrights and restrictions in use (95 %) and (b) cost of the LO metadata record (89 %).
- *Relation*: As far as the relation of the LO with other LOs is concerned, all metadata elements of this category are below the threshold of 75 %; thus, we cannot identify any usually captured information.
- *Annotation*: As far as the annotation of the LO is concerned, all metadata elements of this category are below the threshold of 75 %; thus, we cannot identify any usually captured information.
- *Classification*: As far as the classification of the LO is concerned, the following information is usually captured: (a) the classification system used (84 %) and (b) the terms used from the selected classification system (79 %).

5.4.2 Obligation Status

Since the appearance of an element does not provide a strong indication of its importance, we have also counted whether an element has been defined as mandatory, recommended, or optional in the examined AP. For this purpose, if an element is mandatory, it is weighted with 1.5; if it is recommended, it is weighted with 1; and if it is optional, it is weighted with 0.5. The maximum value that an element can get is 28.5 (if it is mandatory in all metadata APs) and this can be considered as the maximum value of importance for a metadata element in our study. Figure 5.2 gives an overview of the percentage of importance of the metadata elements based on the analysis results. The presentation of elements follows the IEEE LOM categories, but the elements in each category (mentioned with a different color) have been sorted based on their calculated importance as previously mentioned.

As we can notice from Fig. 5.2, the most important information that is captured by all metadata APs is the identifier of the LO (element “1.1.2 Entry”), as well as the title of the LO (element “1.2 Title”), whereas the least important information is the installation remarks that are related with a LO (element “4.5 Installation.Remarks”). These observations are in accordance with Fig. 5.1, where the appearance of metadata elements was analyzed. However, if we consider the metadata elements of each IEEE LOM category and we apply a similar threshold of importance (i.e., 75 % of the maximum importance value), then it is evident that additional metadata elements that are above this threshold are (a) the elements where the language of the LO is stored (75 %) and (b) element where the copyrights and restrictions of use regarding the LO are stored (77 %). All other metadata elements are below this threshold and cannot be considered as important elements within the studied sample of metadata APs.

5.4.3 Value Space

For all metadata elements of the IEEE LOM standard (namely, 18 elements), which have a vocabulary data type, we also studied the modifications that have been performed by the examined metadata APs to the LOM vocabularies of these elements. In order to capture the different types of modifications, we identified three such types: (a) LOM restricted (this means that the values of the initial LOM vocabulary have been restricted to less values), (b) LOM extended (this means that the values of the initial LOM vocabulary have been extended with more values that are not included in the initial LOM vocabulary), and (c) different than LOM (this means that a different vocabulary has been used, which is not related with the initial LOM vocabulary).

In order to quantitatively calculate the modifications, we have used a similar metric with the calculation of the obligation status. This means that if the value space of an element is different than LOM, it is weighted with 1.5; if it is LOM extended, it is weighted with 1; if it is LOM restricted, it is weighted with 0.5; and, finally, if it is same to LOM value space, it is weighted with 0. Figure 5.3 provides an overview of the modifications performed to the value space of the LOM metadata elements.

As we can conclude from Fig. 5.3, the most frequently extended or differentiated, from the IEEE LOM standard, value spaces are used to store (a) the role of the entities that have contributed to the LO (element “2.3.1 LifeCycle.Contribute.Role”), (b) the role of the entities that have contribute to the metadata of LO (element “3.2.1 Meta-Metadata.Contribute.Role”), (c) the type of the LO (element “5.2. Educational.Learning Resource Type”), (d) the intended end user role of the LO (element “5.5 Educational.Intended End User Role”), (e) the educational context/level that

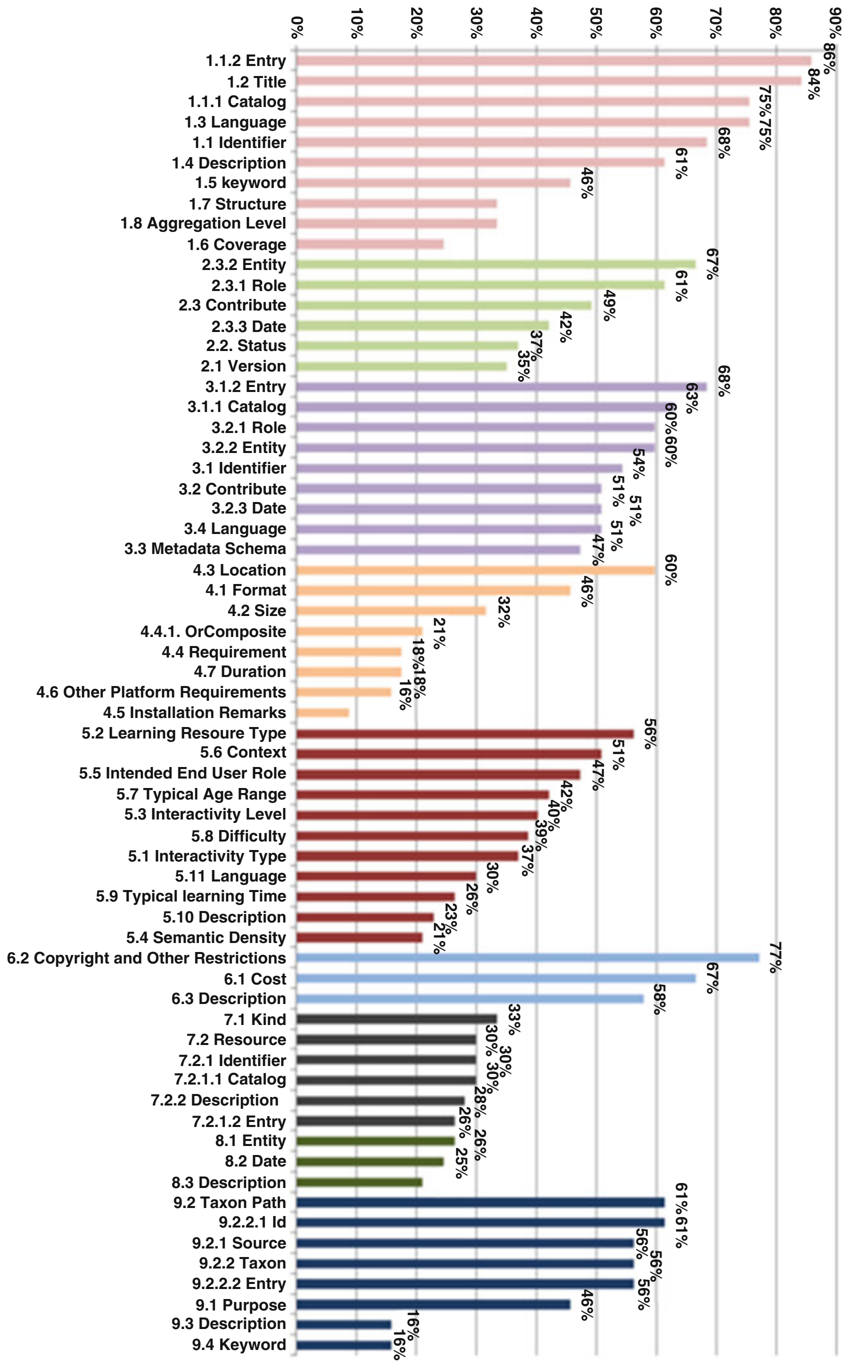

Fig. 5.2 IEEE LOM elements percentage of importance in examined metadata APs

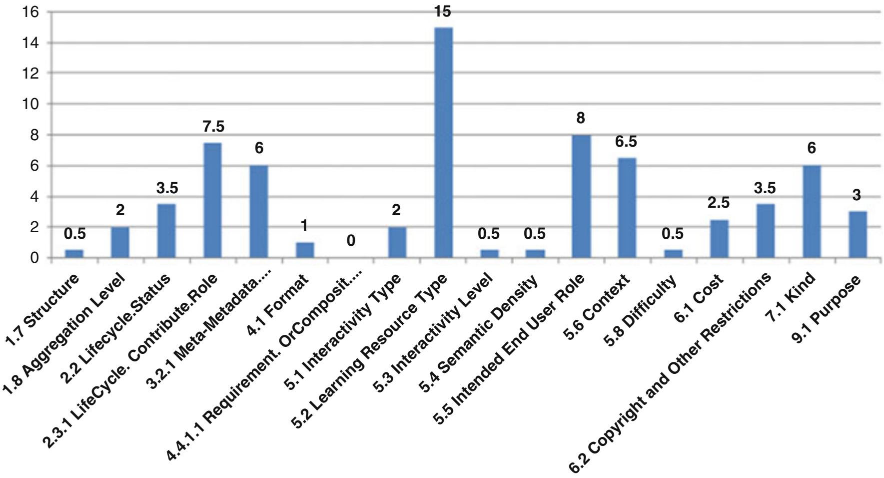

Fig. 5.3 IEEE LOM elements value space modifications

the LO can be used (element "5.6 Context"), and (f) the kind of the relation of the LO with other LOs (element "7.1 Relation.Kind"), whereas the value spaces of all other elements are rarely modified.

5.5 Outcomes and Recommendations

This section discusses the overall observations of the previous analysis and integrates the suggestions into a set of generic recommendations that could be useful for the developers of metadata APs for, at least, European LORs.

An important outcome of our analysis is related to the appearance of LOM elements. If we sort the elements of the examined metadata APs based on their appearance and apply the threshold of 75 % (Fig. 5.4), we can notice that only 28 elements out of the 64 elements of IEEE LOM standard were frequently selected to be included in the metadata APs developed for European LORs. This represents 43.75 % of the total IEEE LOM elements.

Moreover, as we can notice from Fig. 5.4, frequently appearing elements are derived from the following categories: (a) general (7 elements), (b) life cycle (5 elements), (c) meta-metadata (3 elements), (d) educational (6 elements), (e) rights (2 elements), and (f) classification (5 elements). On the other hand, elements from the categories of technical, relation, and annotation rarely appeared and, thus, they cannot be considered as core elements of the IEEE LOM standard. This outcome could provide useful recommendations to the developers of metadata APs when they are selecting elements for developing a new metadata AP (step 1 of the guidelines presented in Sect. 5.3.1).

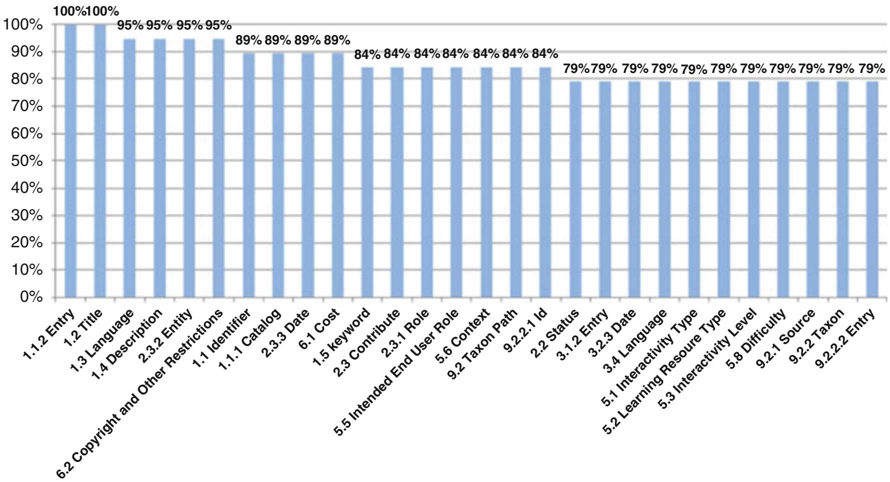

Fig. 5.4 IEEE LOM elements sorted by percentage of appearance

Another outcome of our analysis is related to the obligation status of LOM elements. If we sort the elements of the examined metadata APs based on their importance, we can notice that only 27 elements out of the 64 elements of IEEE LOM standard (i.e., 42.18 %) have a level of importance more than 50 %, as it is depicted in Fig. 5.5. As a result, developers of new metadata APs when they are defining the obligation status of elements for developing a new metadata AP (step 5 of the guidelines presented in Sect. 5.3.1) could consider (a) the elements that have a level of importance less than 50 % as optional (37 elements), (b) the elements that have a level of importance more than 50 % and less than 75 % as recommended (22 elements), and (c) the elements that have a level of importance more than 75 % as mandatory (4 elements). By focusing on the proposed mandatory elements, we can notice that these elements are used in order to store the identifier and the title of the LO, as well as the copyrights and restrictions in use for LO.

Finally, a useful outcome of our analysis is related with the value space of the LOM metadata elements. It seems that (based on Fig. 5.3) only 6 out of 18 LOM elements (33.33 %), which have a vocabulary data type, are frequently extended or differentiated from the value space of the IEEE LOM standard. This means that, for these elements, the vocabulary provided by the IEEE LOM standard is not sufficient to cover the particular needs of different educational communities. As a result, developers of new metadata APs should take this into consideration for performing similar modifications when they are defining the value space of these elements (step 6 of the guidelines presented in Sect. 5.3.1).

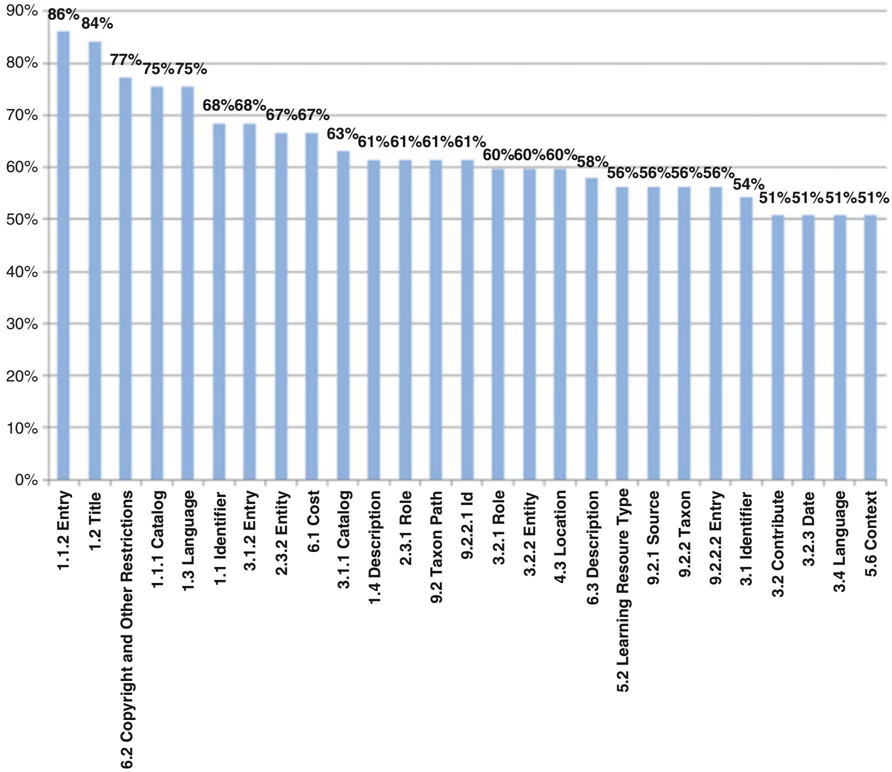

Fig. 5.5 IEEE LOM elements sorted by percentage of importance

5.6 Conclusions

Within the landscape of the currently operating European LORs, it seems that there are not any existing studies that focused on analyzing the metadata implementation on these LORs. Thus, in this chapter it was presented the results of a systematic analysis of metadata APs used in nineteen (19) European LORs. The results of this study could provide useful recommendations for future development of metadata APs. More specifically, developers of metadata APs could be informed about (a) important elements to be included to newly developed metadata APs, (b) the obligation status that the selected elements should receive, and (c) suggested elements for which their value space should be modified. Finally, the results of this study could be useful for the development of the metadata AP of the Open Discovery Space Project (http://www.opendiscoveryspace.eu/), which aims to build a federated network with the different LORs that were presented in Table 5.1 of this chapter.

Acknowledgments The work presented in this chapter has been partly supported by the Open Discovery Space Project that is funded by the European Commission's CIP-ICT Policy Support Programme (Project Number: 297229).

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Part II
The Emerging Technologies Supporting TEL

Chapter 6
Gesture-Based Technologies for Enhancing Learning

Nian-Shing Chen and Wei-Chieh Fang

Abstract Gesture-based computing has received great attention in educational technology. Increasing studies have attempted to integrate its major features—gestures and body motions—into learning activities ranging from physical-related domain to cognitive domain. Despite the rise of gesture-based computing, studies in psychology have long shown that gestures influence the way we learn, think, and perceive the world. Theories of embodied cognition have been the basis to explain the effect of the body on our mind. Thus, this chapter attempts to explore the relationship between these theories and technologies by presenting (1) the ways of interacting with computers using gesture-based computing, (2) the overview of the theories and findings from psychology and education and the implementation of these theories in our own study cases, and (3) potential research frameworks for future studies. It is hoped that researchers and system developers will benefit from this chapter and reflect on how to design an effective gesture-based learning system.

Keywords Gesture-based learning • Embodied learning • Embodied cognition • Natural user interfaces

6.1 Gesture-Based Technology: New Ways of Interacting with Computer

The field of human-computer interaction (HCI) has gone through two major paradigm shifts in the last two decades, from command line interfaces (CLIs) with keyboards as the sole interaction method to graphical user interfaces (GUIs) with

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R. Huang et al. (eds.), *The New Development of Technology Enhanced Learning: Concept, Research and Best Practices*, Lecture Notes in Educational Technology,
DOI 10.1007/978-3-642-38291-8_6,

mouse and keyboards being the main interaction method. Recently, a third paradigm shift has become evident, based on natural user interfaces (NUIs). NUIs are aimed to enable users to communicate with computer systems in a more natural way, similar to what we do in real world (Malizia and Bellucci 2012). Blake (2011) defined this kind of interface as "a user interface designed to reuse existing skills for interacting directly with content." The operation of a natural interface is expected to be more intuitive for the interaction it enables. For this purpose, ICT technologies are rapidly emerging to support natural user interactions to go beyond the traditional interfaces by incorporating different forms of interaction such as multi-touch, eye tracking, voice, gestures, handwriting, etc. (Wojciechowski 2012).

Gesture-based interaction is one rapidly developing area, known as gesture-based computing, in which the human body is used as the main input device. It allows users to interact with a wide range of devices, such as mobile phones, tablets, game consoles, or computer systems. The interaction is through minimal intermediary input devices, such as motion sensors, data gloves, and gravity sensors, through natural user interfaces. The application of gesture-based technology centers not only on using hand and body as input but also on their potential impact on the cognitive and physical-related dimensions.

Microsoft's motion-sensing sensor, Kinect, for example, enables users to physically and cognitively engage in virtual activities in an intuitive way. Users can use their body to perform a task without mouse and keyboards. Kinect also provides many advanced natural user interface features such as spoken commands or presented objects, facial tracking, and speech recognition. With these functions available, numerous studies have incorporated gesture-based technology as enabling or assistive technology for different educational purposes, such as classroom instruction (Chang et al. 2013), memory enhancer (Chao et al. 2013), physical rehabilitation/therapy (Chang et al. 2011b), physical education (Vernadakis et al. 2012), vocational training (Chang et al. 2011a) and language learning (Kuo et al. 2014; Chang et al. 2014), etc.

However, "how would a gesture-based technology benefit learning" is a challenging question for novice researchers and system developers in education. Thus, the aim of this chapter is to explore this question. This chapter is divided into four sections. In Sect. 6.1, the characteristics of gesture-based technology were explored. In Sect. 6.2, evidence from educational research and psychology to show learning benefits with the use of gesture is discussed. Then, our own studies attempting to use gesture-based technologies in education are presented. In Sect. 6.3, two potential research frameworks tapping into different types of gestures and learning variables are proposed with implications for future research and practices. It is hoped that after reading this chapter, readers can gain a general idea about how the gesture-based technologies might be applied and what theories to be based on for their studies and finally relate or associate their own studies with the studies overviewed here.

6.1.1 The Main Characteristics of Gesture-Based Technology

Gesture-based technology is within the scope of natural user interfaces with an emphasis on the use of body-related input. Although gesture-based computing has not yet been clearly defined, Horizon report (2012) refers to gesture-based computing as a new technology that "allows users to engage in virtual activities with motions and movements similar to what they would use in the real world," with voice recognition being part of this emerging development. This body-based interaction with the computer is made possible with the use of different sensors, such as gravity sensor, infrared sensor, and structured-light 3-D sensor, that enable the following features (Horizon report 2012):

- It enables gesture recognition.
- It enables voice recognition.
- It determines position, acceleration, and direction.
- It reads visual markers.
- It reacts to shaking, rotating, titling, or moving.
- It allows the body and hands to be the input devices.

These features mainly change the way we interact with computers. The use of gestures as the control command can enhance stimulus-response compatibility that can give the user a better sense of direct manipulation. In traditional interfaces, the mapping between control device, for example, mouse, and the resulting digit effect, for example, moving of the mouse, is arbitrary and has one-to-many meanings. For example, when manipulating an avatar in a Google map simulation, a mouse is used as an intermediate input device to interact with the icon for controlling the direction of the avatar. In NUI, on the other hand, the bodily input can be meaningful and directly corresponds to the resulting effect. The bodily input, including gestures and the act of walking, can be used to control the avatar as if the user was personally walking in the virtual environment. The mapping between the control input and resulting effect is more intuitive, direct, and compatible in the NUI than in the traditional interfaces.

Beyond using gestures as input, gesture-based techniques can also provide hands-on learning opportunities. Since the gestures and body motions are the main involvement, gesture-based techniques can serve as enabling or assistive technology for physical learning, ranging from rehabilitation, physical education, and physical fitness. It could also facilitate procedural learning that constitutes certain steps of actions and that heavily depends on body-based experiences. Moreover, including body in a learning activity has the potential for enhancing experiential learning. In traditional interfaces, learning takes place in virtual reality or computer simulation where learners learn without body-based experiences. Gesture-based technology enables learners to actively and physically take part in learning.

While gesture-based technology appears to bring more direct user interfaces and involves body control, it is important to understand how gesture-based technologies could influence the ways of learning. The particular aspect of interest is how physical involvement can help to enhance learning. Thus, the following section reviews the theories and findings from body-based studies in education and psychology and then presents the findings from our own design cases using gesture-based technology in education.

6.2 How Gesture-Based Technologies Benefit Learning

This section will first discuss embodied theories that support the involvement of body in learning and then present studies that are in line with these theories.

Since gesture-based technologies mainly involve gestures, or body motion, embodied cognition has been widely used to support the physical effect on learning. Embodied cognition focuses on the "interaction between perception, action, the body and the environment" (Barsalou 2008), which is different from the traditional perspective where body plays little role in cognition. Studies in line with embodied cognition have observed different roles of actions in cognitive processes and have suggested that human mind is closely connected to sensorimotor experience. The roles of sensorimotor experience in cognition and their findings are presented in Table 6.1. Actions, gestures, and body motions will be used intermittently in this chapter to represent the involvement of sensorimotor. Moreover, to explore the potential of gesture-based technologies in learning, we designed four systems to promote optimal body experience and examined their impacts on learning.

Table 6.1 Theories in line with embodied cognition

Roles	Findings	Design case
Body experience as part of learning	Gestures can enhance memory (Smith and Gasser 2005; Barsalou 2008)	Embodied play to learn English vocabulary
	Concepts can be learned through physical experience (Kontra et al. 2012)	Gesture-based simulated practices to acquire optics knowledge
Body as part of *online cognitive process*	Body can cause changes in cognitive processes being carried out during a task (Barsalou 2008)	Spatial problem solving through bodily interaction
	Gestures can be used to support cognitive resources by allowing more effort to be invested at the task (Goldin-Meadow and Wagner 2005)	Gesture-based navigation to enhance listening comprehension

6.2.1 Actions Experience as Part of Learning

Theories of embodiment have proposed that our mind can be affected by action experience. Action experience is referred to "the long-term accumulation of expertise or to salient short-term experience" (Kontra et al. 2012). For long-term, action experience can have impact on our perception of the world. For short term, any action experience continues to have effect on learning and development throughout the lifetime. This is also in line with the concept of experiential learning proposed by Dewey (1938), which values hands-on opportunities as part of an active learning process. The first category focuses on the impact of body-based experience on learning and two implications are explored as follows.

First, psychology studies have found that learners who gesture retain what they have learned more than those who do not gesture (Cook et al. 2008; Macedonia and Knösche 2011), which suggests that body experience can enhance retention. The mechanism behind this might be that actions add action information to the mental representations (Goldin-Meadow and Beilock 2010). For example, Cook et al. (2008) conducted a study to examine whether using gestures when encoding would influence subsequent recall of the information. In their study, elementary learners were taught to use an equalizer strategy for solving math problems (e.g., $4 + 3 + 6 = \_\_\_ + 6$) with gestures (e.g., moving right hand under the left side to the right side of the equation) or speech (e.g., saying, "I want to make one side equal to the other side"). Results from the 4-week delayed test showed that those who used gesture learned the math strategy and solved more math problems than those who used speech. This finding suggests that speech leads to fleeting memory while gesture can help retain the new knowledge.

6.2.1.1 Case 1: Embodied Play to Learn English Vocabulary

The main goal of this study was to explore the feasibility of using Kinect to promote memory performance (Chao et al. 2013). A body-based system was developed, in which participants were led to mesmerize a list of action phrases (e.g., cut a cake) by acting them out (Fig. 6.1). Another mouse-based system was also developed, in which the same memory task was given to the participants without having them act out. An immediate free recall and a delayed free recall test, just to report part of the study, were given to compare the effects of the body-based and mouse-based systems on retention. It was found that there was no significant difference between using the two systems on the immediate recall task. However, on the delayed recall task, there was a significant difference between the two groups: While the recall scores dropped significantly for the mouse-based group, the recall scores did not for the body-based group (Fig. 6.2).

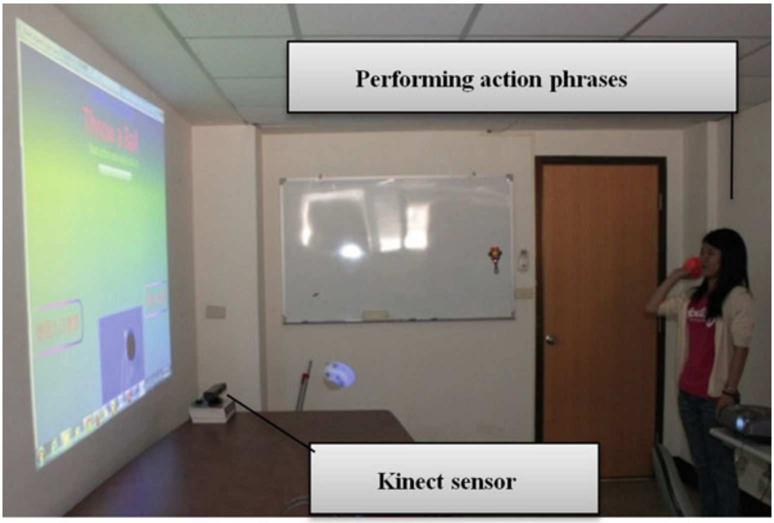

Fig. 6.1 Gesture-based system leading enactment of action phrases

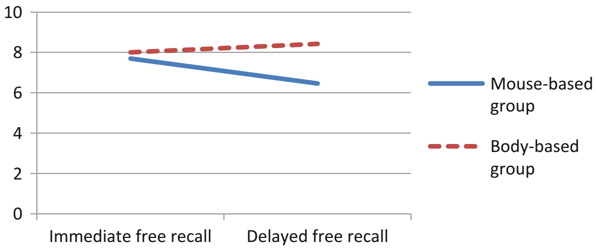

Fig. 6.2 Comparison of mean scores of the two groups on the free recall tests

This result shows that the body-based system successfully helps to sustain the retention of vocabulary learned. Although this effect of the body-based system might not lead to immediate benefits when compared to that of the mouse-based system, for long-term, the benefit becomes obvious in that the retention for the body-based group does not decay as much as that for the mouse-based group.

Second, researchers have proposed that concepts can be realized through physical experience. Studies have found that the understanding of concepts in physics, math, and chemistry can be facilitated by hands-on experience (see Kontra et al. 2012, for a review). The mechanism behind this might be that motor experience can ground mental representations in motor areas of the cortex and structure-associated perception (Kontra et al. 2012). For example, Kontra et al. (2012) conducted a study to examine whether specific motor experience can facilitate understanding of physics. In their study, learners were asked to either personally take part in or observe while learning a physical phenomenon called angular momentum.

Before and after the learning session, a Torque Judgment Task measuring their understanding of factors influencing changes in angular momentum was given. Results showed that those who had hands-on experience outperformed those who merely observed on the judgment task.

Other studies have suggested that abstract domains, such as tempo and pitch, can be acquired with the support of embodied metaphor (Bakker et al. 2012). An embodied metaphor is referred to the interaction between a target domain and a source domain, which can be used to understand an abstract concept (i.e., tempo) in terms of physical schemata (i.e., speed of moving the body). The underlying mechanism is that abstract concepts can be learned by making embodied metaphors to extend the conceptual schema (Lakoff and Johnson 2008).

6.2.1.2 Case 2: Gesture-Based Simulated Practices to Acquire Optics Knowledge

The main goal of this study was to provide gesture-based simulated practices for learners to acquire optics knowledge (Hung et al. 2014). Two systems, gesture-based and mouse-based, were developed to examine the effectiveness of gesture-based simulated practices. Both groups were first presented with the basic optics knowledge and then were engaged in an interactive inquiry activity in which learners observed refraction of light and single-lens imaging through the virtual concave and convex lens (Fig. 6.3). Those in the gesture-based group directly used hands to manipulate the angle of or distance between objects, while those in the mouse-based group did so through the control of a mouse. A pre- and a posttest were given to measure the knowledge gain. With prior knowledge controlled for, the posttest showed that the body-based system led to better knowledge gain than the mouse-based system (Fig. 6.4).

This result suggests that the gesture-based system helped learners to better understand the concepts of the optics through the simulated practices. Since the functionalities between the two systems were the same except for the involvement of the gestures, it can be concluded that gesture-based observation can enhance the comprehension of abstract concepts in physics by making learning a highly content-related process when compared to mouse-based observation.

6.2.2 Action as Part of the Cognitive Processing

Not only can actions help to enhance learning through motor-sensory experience, they can also facilitate online cognitive processing. Different from the aforementioned perspective where body enhances learning experience, actions can have a direct effect on the task being carried out. Wilson (2002) proposed that this kind of task involves online cognitive activity, which requires task-relevant inputs and outputs in real environment (see Wilson 2002). Action, thus, plays an integral part

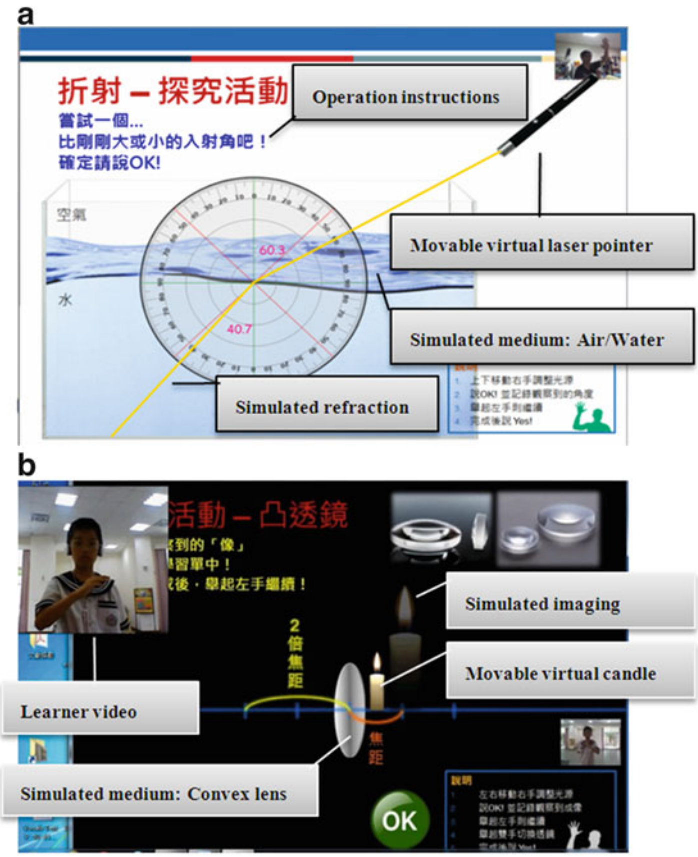

Fig. 6.3 Gesture-based system enabling an interactive inquiry activity. (**a**) Simulated practice for observing refraction of light. (**b**) Simulated practice for observing single-lens imaging

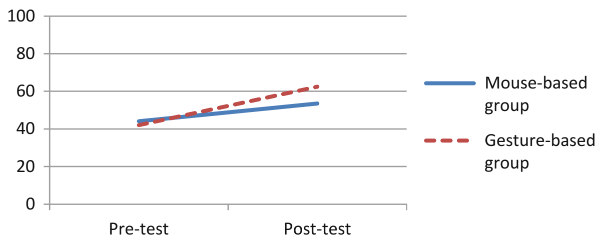

Fig. 6.4 Learning performance of the two groups on the pre- and posttest after the interactive inquiry activity

in the real-time interaction with the environment. The second category focuses on the immediate impact of action on cognitive processing.

First, studies suggest that actions can facilitate cognitive processing while our body is involved during an ongoing task. Actions have been found to facilitate inference when actions are associated with the task at hand (Schwartz 1999),

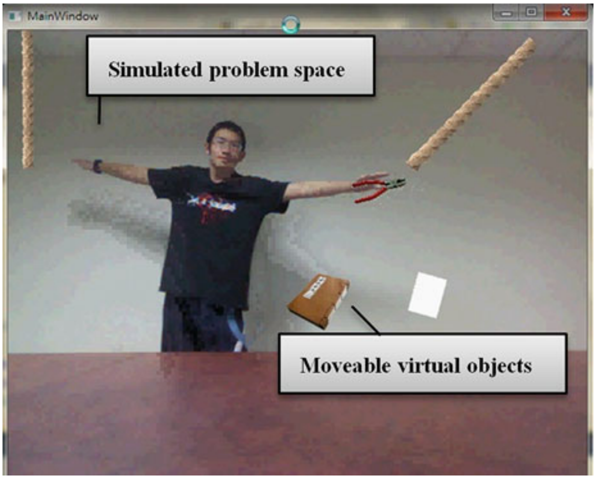

Fig. 6.5 Gesture-based system allowing for embodied interaction during the problem-solving process

reading comprehension when real objects are enacted (Glenberg et al. 2004), and recall of words when gestures are related to their meanings (Krauss 1998). The possible mechanism is that the input might activate the mental representations in a multimodal way (see Barsalou 2008). A study examining the causal effect of action on a spatial-related problem solving found that carrying out actions related to the problem task leads to better solution rates than using actions not related to the task (Thomas and Lleras 2009). Note that the participants were not aware of the relation between the actions performed and the subsequent task. The results suggest that performing actions have direct effect on higher-order thinking.

6.2.2.1 Case 3: Spatial Problem Solving Through Bodily Interaction

The aim of this study was to explore the potential use of motion-sensing technology to facilitate spatial-related problem solving (Fang et al. 2013). Two systems, a body-based system and a mouse-based system, were developed for participants to seek possible solutions to a spatial problem task, called Two-String Problem, which requires the activation of spatial thinking (Fig. 6.5). Both systems allowed the participants to manipulate the virtual objects for seeking possible solutions. All the functionalities in both systems were predefined and the same except for the mode of input control, namely, body versus mouse. It was expected that the use of the body would lead to better spatial thinking, which is the key factor to solving the problem. To test this hypothesis, following the problem solving stage, an identical hands-on problem task was given for measuring the completion rates. It was found that the body-based system did not lead to better completion rates than the mouse-based system.

However, to better understand to what extent did the participants think of using a spatial strategy, for example, swinging the string itself during problem solving,

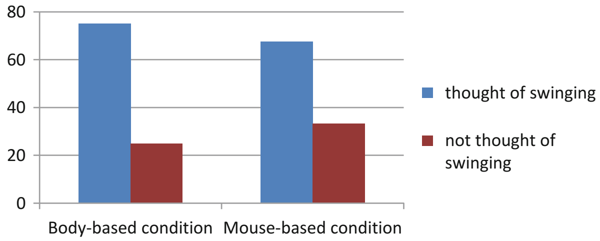

Fig. 6.6 The proportion of swinging the string as a strategy to solve the problem between the two conditions

the thought of swinging the string was considered a sign of activation of spatial thinking and thus examined. It was found that the proportion of swinging to solve the problem in the body-based condition was slightly higher than in the mouse-based condition (Fig. 6.6), although the result did not reach statistical significance. Despite this insignificant result, the body-based system helped participants to feel more confident in solving the problem after using the system, as the expectancies questionnaire indicated that their confidence in solving the problem did not drop significantly, as opposed to the use of the mouse-based system.

This finding suggests that the use of body-based system in facilitating spatial thinking was no more effective than the use of the mouse-based system. Since spatial problem solving involves complex cognitive processes, it might require meaningful strategies to be integrated into the system rather than using actions alone as the means to activate spatial thinking.

Second, research has found that gestures can be used to help reduce cognitive load during a dual task. Goldin-Meadow and Wagner (2005) proposed that gestures can be used to free up more cognitive sources in a way that the verbal store can be shifted onto a visual spatial store. In their study, they had participants do a dual task in which participants were asked to explain how a math task was solved previously while remembering a list of words. It was found that those who used gestures memorized more vocabulary than those who did not use gestures, suggesting that gestures can effectively reduce demands on cognitive recourses and free up more cognitive capacity.

6.2.2.2 Case 4: Gesture-Based Navigation to Enhance Listening Comprehension

This study set out to explore the effects of gesture-based navigation on cognitive load and listening comprehension for EFL students (Hsu et al. 2013). A system using natural user interfaces (NUIs) was developed to implement two types of navigation modes. One was based on mere gesture mode and the other was based on gesture-speech mode combined with the listening strategy which allows for self-paced learning, provides key points, and elicits self-assessment (Fig. 6.7). Another video system using graphical user interfaces was developed to merely allow for mouse control. It was found that there was no significant difference in the scores

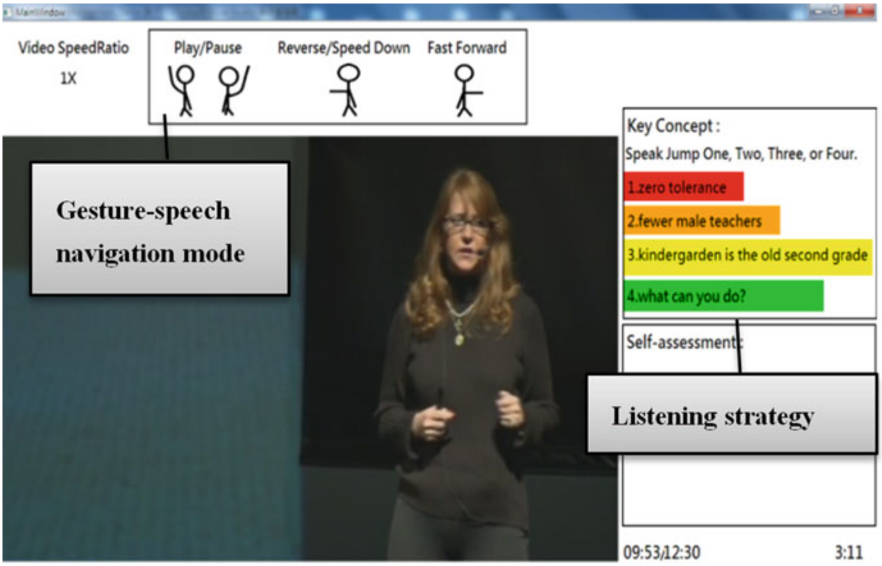

Fig. 6.7 Gesture-based system allowing for gesture-speech navigation combined with the listening strategy

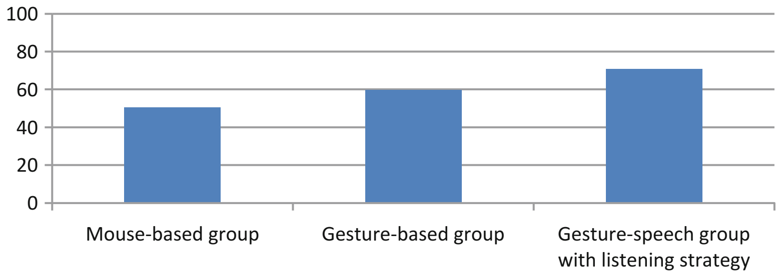

Fig. 6.8 Listening comprehension scores of the three groups on TOEIC with language proficiency controlled for

of listening comprehension between the gesture-based and mouse-based groups. However, a significant difference in the scores of cognitive load was found between the two groups. Moreover, when participants were assisted with listening strategy in the gesture-speech navigation group, they outperformed those in gesture-based and mouse-based groups (Fig. 6.8).

The findings suggest that although gesture-based mode did not lead to better listening comprehension, it helps to reduce the cognitive load during the task being carried out. However, with the integration of learning strategy into the gesture-speech mode, listening performance was improved, which suggests that learning strategy is needed for enhancing the listening task.

6.3 Potential Research Frameworks in Gesture-Based Learning

Having explored the general effects of physical involvement, our research team attempts to propose two possible research frameworks where different types of gestures, body motion, and individual variables are taken into consideration during the design of a gesture-based learning system (Fig. 6.9). Since gestures can be broadly categorized into (a) pointing gestures, (b) representational gestures, and (c) metaphoric gestures (Alibali and Nathan 2012), they can be separated from body motion and strategically integrated into learning activities according to the nature of the subject matters. Moreover, learner variables, such as learning styles and cognitive styles, have been found to play a role in individual learning in the e-learning environment (Chen et al. 2011; Hsieh et al. 2011; Huang et al. 2012). However, whether learning styles or cognitive styles would mediate the effectiveness of incorporating the gestures or body motions into the gesture-based learning system is still an open question.

6.3.1 Learning Through the Appropriate Gestures

The first framework proposed that learning outcomes might be optimized when there is a match between appropriate gestures and subject matters in the gesture-based learning environment (Fig. 6.9).

Gestures have their distinct functions in communication, while different subject matters might benefit from different gestures in learning. Pointing gestures serve to refer to an item in the physical world. Representational gestures represent mental simulations of action and perception, that is, using hands to shape a square as one is thinking about a three-dimensional cube. Metaphoric gestures are used to express an idea, or a concept, via body metaphor, that is, having hands widely extended to express big while having palms nearly close to each other to suggest small.

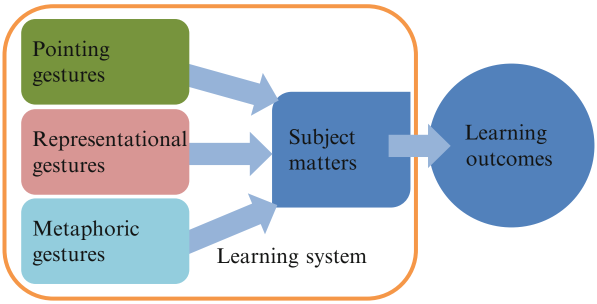

Fig. 6.9 Potential research framework for learning through appropriate matching between gestures and subjects

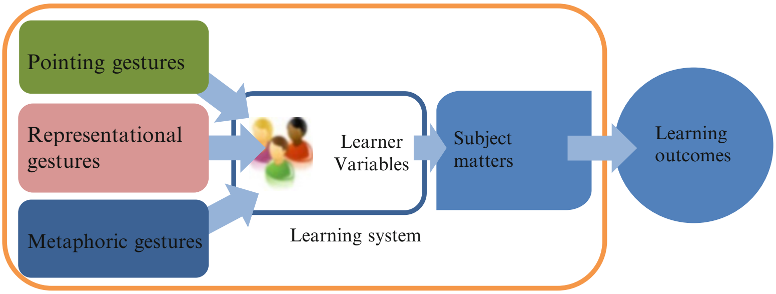

Fig. 6.10 Potential research framework for learning through appropriate matching between gestures and learner variables

Subjects that involve association between concepts can benefit from pointing gestures. Taking language learning for example, one can point to an item in the simulated learning environment, or even the mixed reality, to interact with the learning content. Other subjects that require abstract understanding, such as science and physics, or involve hard-to-perceive perception, such as rhythm and phonological awareness, can benefit from representational and metaphoric gestures that help them to embody their thinking.

6.3.2 Learning with a Match Between Learning Styles and Gestures

The second framework proposed that learner variables might affect the effectiveness of gestures on learning outcomes in the gesture-based learning environment (Fig. 6.10).

Individual variables such as learning styles can convey how a learner learns and prefers to learn (Keefe 1991). Felder and Silverman (1988) proposed a learning style model that includes one dimension tapping into learner's active or reflective learning preferences. Active learners prefer learning by doing while reflective learners prefer learning by thinking. Putting in the gesture-based learning context, it is likely that active learners might make use of gestures or hands during learning while reflective learners would just imagine or simulate the learning content in mind instead.

Another learner variable is cognitive styles that have been found to show how a learner seek and process information (Frias-Martinez et al. 2008). Witkin et al. (1977) proposed a measure tapping into whether learners are field-dependent (FD) or field-independent (FI) styles. Field-dependent learners tend to process information by making use of the cues from the learning environment, while field-independent learners can do so without relying much on these cues. In the gesture-based learning environment, it is possible that FD learners might benefit more from the use of the gestures to interact with the virtual or simulation, while the FI learners might be less inclined to use gestures during such an interaction.

6.4 Conclusion

In the cases presented above, we have designed different projects to explore the potential use of gesture-based technology in learning. We have also identified some mechanisms underlying embodied learning that support these designs. While there were studies that display positive effects of gestures on the learning-related activities, as Cases 1 and 2 indicated, there were studies that did not, as Cases 3 and 4 showed. This chapter contributed to examining the application of the latest developed motion-sensing technology based on some common assumptions that actions play a role in (1) building experience beneficial to learning and (2) having an immediate impact on the cognitive processing.

Based on our own findings, it appears that gesture-based technologies have the capacity to enhance body-related experience. As is indicated in Case 1, participants, who performed actions associated with vocabulary recalled more than those who did not. In Case 2, participants, who were led to perform hands-on optics observation through their gestures, showed more optics knowledge gains than those through the use of keyboard and mouse. These results suggest that gesture-based technologies are effective in implementing embodied learning in a way that (1) motor experience can enrich mental representations and (2) motor experience can enhance the realization of abstract concepts.

Moreover, gesture-based technologies might benefit learners less when the purpose is to promote physical involvement so as to directly affect the cognitive processing. Although psychology literature has suggested that gestures can affect online cognitive processing in a way that (1) task-related mental representations can be activated and (2) the cognitive load can be reduced with the use of gestures, it seems that the gesture-based technologies did not lead to satisfactory results. In Case 3 where gestures were expected to elicit spatial thinking, participants who used gestures to solve a spatial-related problem did not outperform those who used the mouse. In Case 4 where gestures were expected to free up more cognitive sources for listening comprehension, participants who were allowed to use gestures to control the video system did not score higher in the listening task than those who used the mouse, though their cognitive load was observed to be lower when the gestures were used. These findings suggest that it is rather challenging for the gesture-based technologies to facilitate immediate effect of actions on cognitive processing. Our reflection is that integrating learning strategies into a gesture-based system is necessary to optimize the effect of actions.

Finally, the two aforementioned dimensions of actions should not mutually exclude each other. For example, after learners have gained motor experience, it should be easier for them to retrieve the experience related to the action that is being executed. This compatibility between the previous motor experience and the relevant actions involved in a task has been found to enhance the task performance (Goldin-Meadow and Beilock 2010), although the incompatibility would negatively affect the performance. Moreover, in terms of how technologies can be used to facilitate learning, the body-based benefits should not be limited to those covered in this study. One dominant domain that can directly take advantage of gesture-based technology is motor training, such as physical education (Vernadakis et al. 2012), physical rehabilitation (Chang et al. 2011a, b), and physical training (Fang in press).

For future studies, two research frameworks are proposed to examine the effects of different types of gestures, namely, pointing gestures, representational gestures, and metaphoric gestures, on learning outcomes. Moreover, learner variables, such as learning styles and cognitive styles, should be investigated to explore whether there is an interaction between learner variables and gesture types in the gesture-based learning environment. It is hoped that a learning system appropriate for a specific subject matter can be developed under the potential frameworks.

Apart from the benefits of gesture-based technologies in learning, there were some design issues arising from our experiments. We thus propose three design guidelines for bettering the future system design. First, voice command can be used to expedite navigation. Since the left click is absent in the gestural interfaces, to trigger functionality, a different mechanism such as the use of hover circle might be needed. Using it for menu selection can be time-consuming. It is recommended that voice commands be used as the functionality of "select," for example, by saying "okay." Second, embodied interaction should be part of the learning activity. As gesture-based technology features motion recognition, this feature should be well leveraged to enhance experiential learning. Third, feedback should be constantly provided. Since gestural interfaces and graphical user interfaces differ greatly in the interface and the control mode, user needs to adapt to this new interaction. Moreover, gestures vary greatly from user to user which might not fit the predefined ones. As a result, more undesired exploration, idle and false trigger could hinder the system operation, as have been observed in our own studies. Thus, instant guided feedback should be provided.

This chapter attempts to give a brief overview of what the common gesture-based applications are, why gesture-based technologies can be beneficial to learning, and how effective gesture-based technologies are in learning and finally a possible research framework for future studies. It is hoped that both novice researchers and system developers will benefit from this chapter that provides a brief introduction to the recently emerging gesture-based technologies.

Acknowledgments This research was supported by the National Science Council, Taiwan, under project numbers NSC 102-2911-I-110-501, NSC 101-2511-S-110-003-MY3, NSC 100-2511-S-110-001-MY3, and NSC 99-2511-S-110-004-MY3.

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Chapter 7
e-Textbook in K-12 Education: A Case Study in Beijing

Guang Chen, Chaohua Gong, Wei Cheng, Xiaoxia Zheng, and Ronghuai Huang

Abstract Information and communication technology (ICT) has made a great impact on traditional textbooks. It is promising that e-Textbooks support significant opportunity for improving the educational practices. In this case study, we identified the potential issues when initiatively utilizing e-Textbook in classes and examined the change from paper textbook class in Technology-Rich Classroom (pTRC) to electronic textbook class in Technology-Rich Classroom (eTRC) from the perspective of effective learning, by analyzing class activity capacity, classroom behaviors, and technology roles, using a mixed-method design of interview, questionnaire, and on-site observation. The results will provide useful suggestions for the policymakers, teachers, school administrators, parents, and so on.

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R. Huang et al. (eds.), *The New Development of Technology Enhanced Learning: Concept, Research and Best Practices*, Lecture Notes in Educational Technology, DOI 10.1007/978-3-642-38291-8_7, © Springer-Verlag Berlin Heidelberg 2014

Keywords e-Textbook • Activity capacity • Classroom behaviors • Technology roles

7.1 Introduction

The rapid development and popularization of information technology significantly increase the speed of the generation of human knowledge, which has brought fundamental impacts on the modes of education and the methods of instruction. The traditional ways of learning are facing a revolution to adapt to the requirements of the information age. In order to facilitate easy, engaging, and effective learning for the learners, current digital learning environment is gradually evolving into the intelligent learning environment. As the higher mode of digital learning environment, it has significant diversities in six aspects, including learning resources, learning tools, learning communities, faculty communities, learning methods, and teaching methods, among which teaching material is the basic element of the intelligent learning environment (Huang et al. 2012a) and its reform is the key to promote the development of education and instruction. Studies have shown that information technology has been gradually changing the brain structure and cognitive style of human beings (Small et al. 2009). The new generation of students growing up with computers and the Internet are often referred to as "digital native" or "net generation" (Bennett et al. 2008), who have fast information retrieval capability, are better at handling a variety of tasks at the same time, and like to seek novel excitement but also have the problems like uneasy to concentrate (Small and Vorgan 2008). At this background, in specific educational scenarios, the inevitable conflicts between the inherent stability, closure, and statics of traditional paper-based textbooks and the diversity, openness, and dynamics of modern educational scenarios become increasingly significant. Therefore, the research, development, and application of e-Textbook become the major research projects of current educational and instructional reform.

7.2 What's e-Textbook?

In terms of terminology, e-Textbook is an electronic textbook, which is just the electronic form of paper-based textbook in the early stage, for example, using tapes, CD-ROM, and network as the carrier for textbooks, using multimedia technology to enrich the content and expression form of textbooks (Meng and Zhou 2001; Zhou 1998). The "e-Textbook" mainly in the forms of CAI courseware or teaching application software is quite different from the e-Textbook discussed in this chapter. So far, there is no unified definition on the concept of e-Textbook. (1) Some researchers emphasized the attribute of e-Textbook as digital resources: Lv (2009) believed that e-Textbook is another version of paper-based textbooks, and Jung (2009) pointed out that e-Textbook is to store the digitalized contents of paper-based textbook in the electronic media for users to read, watch, and listen to on the Internet. (2) Some researchers are concerned about the rich-media feature of e-Textbook: Xu and Liu (2003) believed that e-Textbook integrates a variety of texts, images, audios, and video files, which can easily realize the experiments and dynamic demonstration process that are difficult to achieve in the traditional paper-based textbooks and teaching methods to help students understand the key and difficult points; Xiang (2005) believed that the existence of e-Textbook as Web pages was available for repeat uses by teachers, students, and parents, without the limitations of time and space, whose data were updated fast and timely with the features of sharing, openness, and dynamic generation. (3) Some researchers examined the application of e-Textbook from the perspective of e-books and teaching system. Porter (2010) considered that e-Textbook integrated electronic reading software with the contents of e-books. Zhu and Yu (2011) interpreted e-Textbook as a special type of e-book which had standards for the functional attributes of textbooks in reading and teaching. Li et al. (2011) believed that e-Textbooks were the teaching system developed based on information technology and multimedia technology.

To meet the requirement for teaching and learning from Chinese K-12 schools, Chen et al. (2012) stated that e-Textbook was a special kind of e-book developed according to curriculum standards, which meets the students' reading habits, facilitates organizing learning activities, and presents its contents in accordance with paper book styles. Actually, e-Textbook has been available to educational institutions for many years in developed countries. In Japan, the Ministry of Internal Affairs and Communications (MEXT) proposed the deployment of e-Textbook to all elementary and junior high school students by 2015, in the "Haraguchi Vision," in late 2010. In Korea, the "Education and Human Resources Development Ministry" and the "Education and Research Information Service Korea" have been developing digital textbooks under the policy of "Government's Plan to Introduce Smart Education." In this policy, e-Textbook scheduled to be introduced into elementary and junior high school by 2014. According to a report published in USA Today, the Obama Administration is advocating the goal of an e-Textbook in every student's hand by 2017. With the emergence of utilizing e-Textbook initiatives on the rise, it is promising that research has found that e-Textbook supports significant opportunity for improvement within the educational setting.

7.3 Research Motivations and Questions

Few studies have investigated the use of e-Textbook for elementary school students (Huang et al. 2012b). According to survey concerning the feasibility of e-Textbook in K-12 schools in Beijing (Gong et al. 2012), it has been claimed that 88 % of the 144 teachers and 97 % of the 516 students and all the 25 parents thought that it was feasible to utilize e-Textbook in classrooms. Both teachers and parents were also concerned with the challenges to be faced in utilizing e-Textbook in K-12 classrooms, especially with the device stability, user experience with e-Textbook, visual fatigue from staring at small screen, learning process management, etc. Teachers, policy-makers, and parents had great concerns with whether e-Textbook could keep the classroom as smoothly as before.

Besides, in recent years, various issues of classroom instructional activities have been widely discussed owing to the rapid advancement of digital technologies. Technology-Rich Classroom is a technology-enriched learning environment, which can range from simple computer classrooms to extravagantly appointed classrooms equipped with computers, projectors, Internet access, and communications technology allowing for distance and real-time access to a vast array of resources. To date, however, studies of electronic textbook class have not provided adequate information in two areas: (a) descriptions of electronic textbook class that are effective for students' learning and (b) the effects of technology roles and classroom instruction. In this context, the comparison between paper textbook class in Technology-Rich Classroom (pTRC) and electronic textbook class in Technology-Rich Classroom (eTRC) is worthy of being explored and discussed.

So we did a research to explore what factors may influence the utilization of e-Textbook in K-12 classrooms initiatively through a mixed-method design research in two pilot schools. And an attempt was made to seek the changes between paper textbook class in Technology-Rich Classroom (pTRC) and electronic textbook class in Technology-Rich Classroom (eTRC) in three respects. The research question consisted of six key issues, as follows:

- What technical issues will influence a class running smoothly?
- What factors will influence the user experience from the teachers' view and students' view?
- What challenges will be faced when teachers are preparing e-Textbook classes?
- Is there any change of class activity capacity between eTRC and the previous pTRC?
- What changes transpired between the teachers' and students' behaviors that happened in eTRC compared to pTRC?
- Is there any difference in the technology roles between eTRC and pTRC?

7.4 Methodology

7.4.1 Research Framework

In this case study, we conducted two sub-researches. One is an experiment to identify the potential issues when initiatively utilizing e-Textbook in class by using a mixed-method design of lecture video coding, interviews, and questionnaires; the other is a research to examine the change from paper textbook class in Technology-Rich Classroom (pTRC) to electronic textbook class in Technology-Rich Classroom (eTRC).

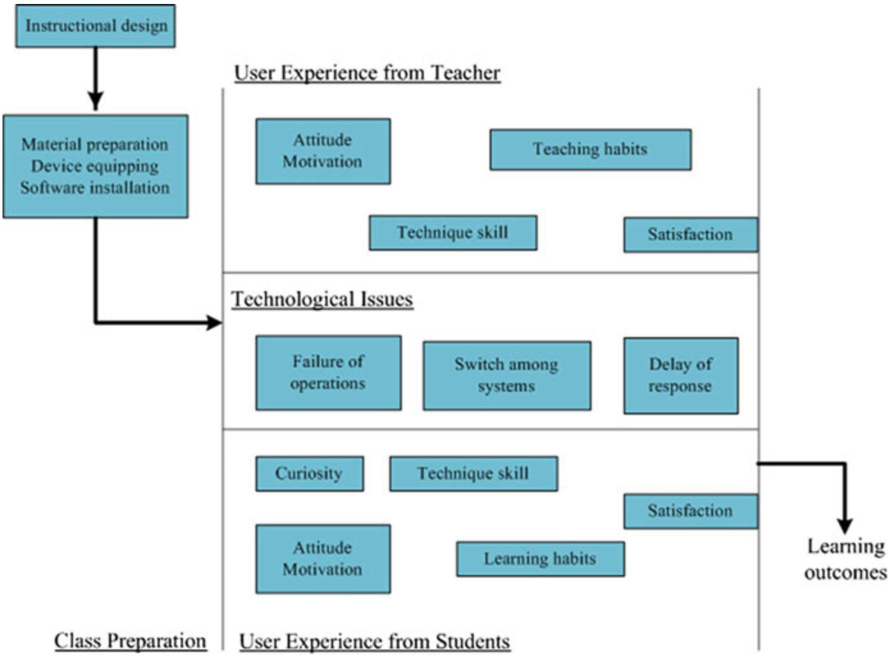

Fig. 7.1 The research framework for e-Textbook in classroom

In order to analyze the potential issues of initiatively utilizing e-Textbook in K-12 classrooms, we proposed the four components to assess e-Textbook in classrooms: technical issues, user experience from teachers, user experience from students, and class preparation (as shown in Fig. 7.1). Teachers need to prepare classes carefully and earnestly when new technology and new method are involved in the classroom. So class preparation is consisted of four elements, including instructional design, material preparation, device equipping, and software installation. Technical issues, user experience from teachers, and user experience from students are the three aspects to be assessed for using e-Textbook in a class. Technical issues are comprised of operation failure, switch among systems, and delay of response. Factors from teachers' side include attitude, motivation, technique skill, teaching habits, and satisfaction. Factors from the students' side include attitude, motivation, technique skill, learning habits, satisfaction, and curiosity. Also, the learning outcomes need to be considered as a key issue when analyzing the effectiveness of e-Textbook in the classroom.

Besides, in this research, we were also trying to compare the differences from paper textbook class in Technology-Rich Classroom (pTRC) to electronic textbook class in Technology-Rich Classroom (eTRC) in three respects, including activity capacity, classroom behavior, and technology role, as shown in Fig. 7.2. The differences of instructional process between the two settings are the types of textbooks and instructional media. For pTRC, there are 1 computer,

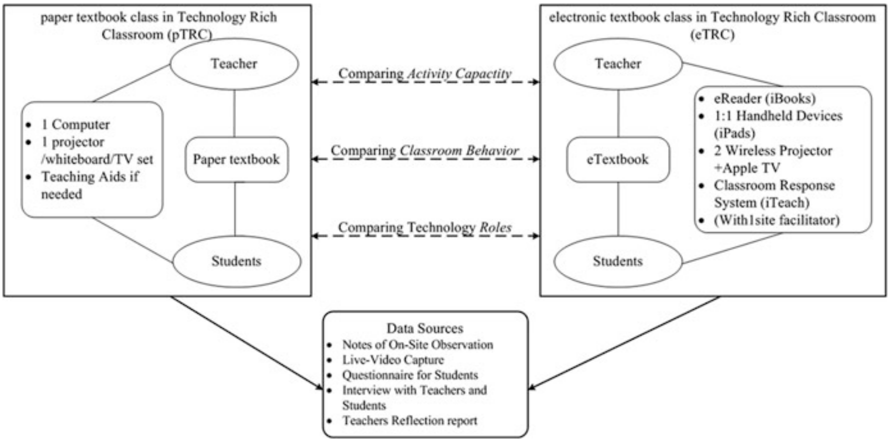

Fig. 7.2 Research framework for comparing between eTRC and pTRC

1 projector/whiteboard/TV set, and teaching aids (if needed). For eTRC, there are e-readers (iBooks), 1:1 tablet devices (iPads), 2 wireless projector + Apple TV, classroom response system (iTeach App), and with a tech facilitator for helping the teachers and students to solve the technical issues.

The primary issue is to identify the three variables of the changes. They can be defined as follows:

Class Activity Capacity (CAC): it refers to the amount of effective learning activities in a class, in which the effective learning activity for a student refers to the process the student completes learning tasks and achieves learning objectives within a certain period of time. So, a learning activity would be calculated if there are three components, such as learning tasks, learning methods, and assessment inclusively, in its process.

For Learner Engagement Indicator (LEI) in a class: the Learner Engagement Indicator for a class refers to the ratio of the weighted sum of the student amount with different number of effective learning activities to the CAC (number of effective learning activities for a class), as is shown in the following formula (7.1):

$$\text{LEI} = (X_1 + 2 * X_2 + \cdots + L * X_L) / (L * N) \tag{7.1}$$

where X_i denotes the number of students whose amount of effective learning activities was completed.

L denotes the class activity capacity, that is, the number of effective learning activities in the class.

N denotes the number of students in the class.

Classroom Behavior (CB): it refers to action or action series in a classroom for both the teacher and the students. Basically, the classroom behavior consists of two categories related to teacher(s) and students, respectively.

Technology Roles (TR): it refers to the functions and benefits of technology involved in a class, which make the class different from the previous one. Herein the technology includes computer network, devices, supportive software, and digital resources in the classroom.

7.4.2 Participants

There were six classes in Grade 4 from two elementary schools in Beijing, China, taking part in the research. Nine teachers (5 from Chinese subject, 3 from English subject, and 1 from Science subject) and 203 students are involved in the first sub-research to identify the potential issues when initiatively utilizing e-Textbook in 14 classes. More than 80 % of the total 203 students involved in this research had experiences in using iPads. And 12 teachers (5 from Chinese subject, 3 from English subject, 2 from Science subject, and 2 from Math subject) and 209 students from six classes were involved in the second sub-research to examine the change from paper textbook class in Technology-Rich Classroom (pTRC) to electronic textbook class in Technology-Rich Classroom (eTRC) from the perspective of effective learning. Since selecting class is a big challenge of comparability, we identified all the lessons with new contents taught and the contents with the same or similar types in comparison to a pair of e-Textbook class and paper textbook class. For each teacher, we collected 2 pTRCs and 2 eTRCs. The class settings are shown in Fig. 7.3. Finally, we collected 24 eTRCs and 24 pTRCs.

7.4.3 Procedures

The research procedures are as follows:

Stage 1: To meet the needs of the research, we suggested each school designate a coordinator who was in charge of constructing the classroom environment with iPads, training teachers and students to use iPads, and helping teachers with instructional design with iPads.

With the support of the coordinator, teachers identified the teaching material and designed the instruction for using e-Textbook in classroom. The school technician or the research team would help to install iTeach App and iBooks App, synchronize the e-Textbook on iPads, as well as equip the classroom with Apple TV, wireless network, etc. Before they used e-Textbook at the first time in class, there was a technical training session for the teachers and students.

Stage 2: We did on-site observations and captured videos for fourteen classes taught by nine teachers to examine the process of instruction and to assess the learning outcomes students achieved. During the classes, there was always a technician to help the teachers and students to solve the technical issues.

After the teachers and students were familiar with e-Textbook, we did on-site observation and video capture for all the classes (including pTRC and eTRC) in

Fig. 7.3 The class settings in the two primary schools

order to examine the changes among activity capacity, classroom behavior, and technology role in classes.

Stage 3: We collected the teachers' reflection documents after class and interviewed the nine teachers for investigating their experiences. We collected questionnaires from all the students and interviewed 20 students for understanding the user experience.

7.5 Findings

7.5.1 Potential Issues on Initially Implementing e-Textbook in K-12 Classrooms

7.5.1.1 Technical Issues

Through video coding, we found some technical issues during the instruction, including technical failures, delay of system response, and switch among systems delay.

In terms of “failure of devices and software,” during the 14 classes, a video analysis showed that the technician helped teachers and students solve technical failures at least 3 times. From the result of technical failures, we have classified possible technical failures into five types, which consisted of the following: (1) LAN failure (students were unable to log into iTeach App with iPad), (2) abnormal exit of iBooks during teachers’ operation, (3) no response of widgets embedded in e-Textbook when students click on this, (4) no response when tapping e-Textbook on iBooks’ bookshelf, and (5) failure to take notes and highlight the texts.

Regarding “delay of system response and switch among systems delay,” we found out that all the 14 classes ran overtime and the longest one was extended more than 5 minutes. The system and software switching time was longer than page loading time. It can also be concluded from video observation that when teachers were switching software, they needed to wait for students to switch to the same software as well. For instance, from one of Ms. Liu’s teaching video clips, she distributed the quiz after all the 35 students in the classroom had logged in the iTeach. Because every student held a learning device like iPad, it took the students some time to switch among the pages assigned by the teachers. Further, for the four teachers with more than one pilot class, we found out that the more times the teachers tried, the lesser the length of time of TD and TS. This finding confirmed to what has been reported in the previous studies; unskillful operation from teachers would lead to overtime of a class. Besides that, the software platform, the diversity of students’ operation habits, and system stability could influence the smoothness of instruction process as well.

Hence, technology is still a key issue for teachers to meet in the classroom, such as more time to spend in refreshing system in case of failure of devices and software and more time to switch among the devices and software due to the diversity of user operational habits, system stability, etc.

7.5.1.2 User Experience from Teachers

The quality of teachers’ experience is a significant issue that influences e-Textbook in the classroom.

According to the interview results, it was concluded that most teachers have a positive attitude toward e-Textbook. The teachers would be easily satisfied if they have weaker teaching habits of depending on paper textbook and stronger skills in operating software and devices.

7.5.1.3 User Experience from Students

From the data of students’ questionnaires, we found that students had high-level experience when using e-Textbook in classroom. Students were highly motivated to use e-Textbook in learning activities because they had burning curiosity and interests in it. From the information gathered from the questionnaires, we also found out that all the students had enough technique skills to control iPad. Another thing we learned was that students felt they were used to e-Textbook class in general and they felt satisfied about classroom learning with e-Textbook.

Twenty of the 203 students were interviewed randomly. We found that students had a positive attitude to using e-Textbook in classrooms. Some other findings are as follows: (1) For "technique skill," almost all the students can use e-Textbook, including turning pages, airplay with Apple TV, highlighting, taking notes, etc. (2) For "curiosity," students were immersed in the rich contents in e-Textbook because of widgets' amazing interactive elements on e-Textbook. (3) There was still a negative impact on the students when watching the videos. A few students would not look at the whiteboard or listen to teachers, because they spent a long time playing with iPad. (4) For "learning habits," all the students said that it made no difference between using e-Textbook and paper textbooks. However, all the boys mentioned that they feel nervous when teachers "called" their names and expect them to raise their hands when they finished the quiz in the class, in case they were asked to project their iPads on the screen.

So, the findings confirmed that e-Textbook would promote students' learning interest. The students would be easily satisfied if they have both a strong curiosity and information literacy.

7.5.1.4 Class Preparation

The interview for class preparation with nine teachers had been carried out after each class, and it revealed the following findings: (1) For "instructional design," all the teachers said that they spent longer time preparing a class when using e-Textbook than using paper textbooks. They needed to consider multiple aspects systematically, such as defining a reasonable and clear learning outcome, studying the functions of iPad, designing learning activities with more interaction, etc. (2) For "material preparation," all the teachers mentioned that they needed to collect a lot of materials to match the requirements when developing e-Textbook. Six of them said that they had difficulties in preparing multimedia materials, such as low-level information literacy, scarcity of useful materials, unskillful of developing contents, etc. (3) For "device equipment and software installation," all the teachers said that they needed a technician to help them equip the devices and install software, such as updating iOS system and iPad Apps, synchronizing contents, setting up projector (Apple TV), etc.

So, it can be concluded that if the teachers have more experiences with instructional design, they would be able to conduct better class preparation, such as defining suitable learning outcomes, designing diverse learning activities, and preparing material, devices, and software effectively.

7.5.2 What Happened to e-Textbook Class in Technology-Rich Classroom

7.5.2.1 Changes on Class Activity Capacity

One of the research objectives was to examine whether there were any changes of class activity capacity between an eTRC and a pTRC or not. According to the necessary conditions for a learning activity (learning tasks, learning methods, and learning outcomes) in a class, we calculated the numbers of learning activities in all the lessons, which were effectively completed as planned. In pTRC, there were 12 out of 24 lessons in which learning activities were effectively completed, which account for 50 % of all the paper textbook classes. In eTRC, there were 17 out of 24 lessons in which learning activities were effectively completed, which account for 71 % of all the e-Textbook classes. The ratio of classes, which effectively completed the learning activities as planed in eTRC, was higher than in pTRC, which increased by 21 %.

In addition, this research also examined the Learner Engagement Indicator in a class. Students were more engaged in learning activities in eTRCs compared to pTRCs ($\text{Min}_{\text{eTRC}} = 0.65$, $\text{Min}_{\text{pTRC}} = 0.26$).

From the interview, we found that technical issues, the complexity of learning tasks, the articulation of learning methods, and the engaged time (time students actually engage in learning tasks) were the main factors to influence the classes in which learning activities were completed.

Therefore, there are changes of class activity capacity between eTRCs and pTRCs. It can be derived that the ratio of classes that effectively completed the learning activities as planned in eTRC is higher than in pTRC, and teachers and students completed the learning activities with the help of e-Textbook and digital devices, which are provided by Technology-Rich Classroom. Further, Learner Engagement Indicator (LEI) in eTRC is higher than in pTRC.

Changes on Classroom Behavior

This research further examined whether there was any change in classroom behavior between eTRC and pTRC or not. With regard to changes of teachers' behaviors, there are significant differences in the items of the total time for transmission and the total time for directing behaviors between eTRCs and pTRCs during all the 48 classes with $p < .01$, as shown in Table 7.1. The total time for transmission behavior was shorter in eTRCs compared to pTRCs. The total time for directing behavior of teachers went higher when using e-Textbook in the classes, compared to using paper textbooks. There was no significant difference regarding to the total time for dialogue between teachers and students in all the classes.

Table 7.1 *t*-test of the time for teachers' behaviors between eTRC and pTRC (units: minute)

Items	Classes	*N*	Mean	S.D.	*t*
Transmission	pTRC	24	10.47	2.04	9.929**
	eTRC	24	6.07	0.74	
Dialogue	pTRC	24	13.16	1.30	2.455
	eTRC	24	12.47	0.76	
Directing	pTRC	24	1.57	0.52	−7.099**
	eTRC	24	2.75	0.63	

$^{**}p < 0.01$

Table 7.2 *t*-test of the time for students' behaviors between eTRC and pTRC (units: minute)

Items	Classes	*N*	Mean	S.D.	*t*
Individual learning	pTRC	24	7.36	1.49	−4.123**
	eTRC	24	8.79	0.82	
Cooperative learning	pTRC	24	6.92	1.78	−9.273**
	eTRC	24	11.20	1.41	

$^{**}p < 0.01$

So, it can be derived that the allocated time (time scheduled by the teacher for a particular lesson) and the actual time used for instructional activities are less in eTRC than in pTRC. The time that is under the direct control of the teacher has been changed, which makes the teachers' behavior changing from transmission to dialogue and directing.

Regarding to changes for students' behaviors, the total time for students' behavior was longer in eTRCs compared to in pTRCs. Further, there are significant differences in the items of the time for individual learning and time for cooperative learning between eTRC and pTRC, ($p < .01$), as shown in Table 7.2.

From the analysis results of classroom behavior, it could be concluded that the total time for teachers' behaviors in classes was shorter than that of students' behaviors. eTRCs could boost the shifting of classroom instructional structure from the teacher centered to the student centered. Further, the interviews with teachers and students revealed the following findings:

- The teachers have the willingness to utilize technology to support teaching and change their teaching behaviors.
- Students are motivated to finish learning activities more initiatively in eTRCs than that in the pTRCs, such as discussing with teachers and classmates, showing works, and doing exercises and quiz.

Therefore, significant changes on classroom behaviors were found from the research, including the total time for teachers' behaviors in eTRCs was shorter than that of teachers' behaviors in pTRCs. Students participate in classroom learning activities significantly, initiatively, and positively in eTRC compared to pTRC.

Table 7.3 Differences of technology roles in eTRC and pTRC

Technology roles	eTRC	pTRC
Showing content	More beneficial to show the contents continuously since at least two screens can be opened at the same time when presenting the teaching materials	Only one screen for presenting the teaching materials with PPT
	More clarity when the students receive the presentation	Learning materials only be showed through discourse and physical projection
	Showing learning materials instantly (students' e-Textbook, works) on the screen via airplay	
Managing environment	A more flexible layout of the chairs and desks, such as semicircle, parallel, straight rows	Mainly straight rows for chairs and desks
	Easier to distribute the teaching materials	Distributing teaching materials one student at a time
Accessing resources	More rapid access to digital resources with iPads since it is integrated with e-Textbook	Taking more time to access to digital resources, since it is separate from the paper textbook
	Digital resources are more adaptive to personalized learning	The digital resources do not match the students' requirements with personalized learning
Real-time interacting	More flexible human computing interaction in real time, for example, student-teacher interaction with iPads is instant; student-student interaction with iPads is instant	Mainly real-time interaction between teachers and students via discourse, role-play
Tracking environment/ learning process	Beneficial for testing the learning environment, including sound effects, lighting, circuitry	Difficult to monitor the learning environment and learning processes
	Beneficial for testing the learning processes, including monitoring the students' note-taking behaviors, degree of engagement	Challenging for creating a personalized learning environment

Differences of Technology Roles

This research examined whether there is any difference in technology roles between an eTRC and a pTRC. The results of interviewing with teachers and students revealed the findings as shown in Table 7.3. It can be seen that both teachers and students are highly dependent on technology for implementing and administrating learning activities in eTRCs.

In addition, the interview results showed teachers had a willingness to utilize technology to support teaching and make the class more effective in a Technology-Rich Classroom. As Mr. Li mentioned "when I am preparing the class, the selection of tools depends on the task at hand and the materials one is working with, I like to use technology to facilitate the students' learning performance." Mr. Zhang also said "I do not need any assistance to use the digital devices to complete my instructional activities."

This finding also complied with what has been reported by researchers that there are a few important benefits of technologies for students in a class, including holding their attentions, motivating students to take actions, increasing their interests for learning, and making learning easier.

7.6 Conclusion

In this case study, we identified the potential issues when initiatively utilizing e-Textbook in classes and examined the change from paper textbook class in Technology-Rich Classroom (pTRC) to electronic textbook class in Technology-Rich Classroom (eTRC) from the perspective of effective learning, by analyzing class activity capacity, classroom behaviors, and technology roles, using a mixed-method design of interview, questionnaire, and on-site observation. The results will provide useful suggestions for the policy-makers, teachers, school administrators, parents, and so on. Although there is no culture difference in our researches, however, if other researchers want to adopt the results, they should be careful that the content of e-Textbook in our research refers to the textbook materials, which are redesigned by the teachers. And we only choose iPad as the learning device for doing the above pilot studies.

This is a tentative research on exploring the changes between eTRC and pTRC in K-12 schools, which need to be investigated on a larger-scale incorporating more samples, and more evidence needs to be collected to confirm the findings of this research.

e-Textbook is the inevitable trend in the development of textbooks. However, e-Textbook has to focus on the issues of research and development, publication, evaluation, effective use, and so on in order to truly be applied in classroom teaching (Huang et al. 2011).

Among the above aspects, the most important is how to effectively use e-Textbook in classroom teaching, so it is necessary to find a series of methodology that is consistent with the learning requirements of students in the information age and the laws of learning and teaching. Therefore, the following issues should attach importance to:

7.6.1 Content Reconstruction of e-Textbook

At present, the design of textbook contents focuses on the design of the sections of assisting learning, textbook contents and exercises. In addition, the specialized teachers' manuals are provided to guide the use of textbooks, and the corresponding workbooks are provided to examine the students' mastery of knowledge points. However, the educators are generally focusing on the complexity and regularity of the changes of the knowledge nature in the educational context and are concerned about the diversity and difference of the changes and the development of knowledge in specific situations and conditions. Therefore, the design of e-Textbook should be problem oriented, take the key knowledge points into consideration, construct the paths of students' acquired knowledge, and reconstruct the textbook contents. That is to say, in a whole, it should explore how to effectively integrate the textbooks, corresponding workbooks, and teachers' manuals into the content reconstruction and layout design of e-Textbook.

7.6.2 The Learning Behavior of Students in the Environment of e-Textbook

The researches of neuroscience show that the brains of the "digital natives" are changing. They like and are also good at dealing with a variety of tasks at the same time. They incisively and quickly receive all kinds of information. They are used to "random access" to the learning habits of knowledge. They prefer games to "serious" and systematical work. And it is important that the rapid development of information society put forward new requirements on the abilities of students. Therefore, researchers have to understand what learning habits the generation of K-12 students as "digital natives" have so as to fully discover the changing regulations of their learning styles and reading habits, their behavioral characteristics of using textbooks in different applicative contexts, and the interactive approaches of textbooks. The access to these important characteristics of learning behaviors can help with the exploration of functional and structural characteristics of e-Textbook and the mutual correspondence between the two parties so as to design the e-Textbook that supports students' autonomous, cooperative, and inquiry learning methods.

7.6.3 The Teaching Behavior of Teachers in the Environment of e-Textbook

While teachers have years of habit in using paper textbooks, as a new presentation form, e-Textbook has to solve the problems such as how to adapt to the old habits of teachers, how to help teachers monitor the learning process of students, and so on. Therefore, researchers have to go to the classroom to understand what typical teaching methods the teachers have in the lesson preparation and classroom teaching, to get familiar with and respect their existing teaching habits, to sort out the characteristics of their teaching behaviors via accessing the behavioral characteristics of their using textbooks, and to dig out the support services provided by the textbooks in the teaching process so as to guide the design of the instructional functions of e-Textbook.

Furthermore, the design of e-Textbook in the future also has to concern about some issues, such as how to ensure the e-Textbook contents are operated in a safe environment, how to consider the impact on the physical and psychological health of students, how to store all data and how to update e-Textbook contents, and so on. Only when all kinds of issues that affect the application of e-Textbook are solved more comprehensively and the laws of learning and teaching are fully respected, it is possible to design the kind of e-Textbook that truly benefits students' learning.

Acknowledgment This research work is supported by National Social Science Foundation of China (2011) project "Potential issues on utilizing e-Textbook in middle school" (No. CCA110107).

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Chapter 8
Context-Aware Mobile Role Playing Game for Learning

Chris Lu, Maiga Chang, Kinshuk, Echo Huang, and Ching-Wen Chen

Abstract This book chapter discusses the research findings of a context-aware mobile role-playing game that can automatically generate personalized context-aware learning activities based on the students' current locations and the surrounding learning objects and the knowledge it covered. Furthermore, the game can automatically create transition stories in between two learning activities. These stories give students immersive learning experiences and make them get engaged in doing learning activities.

Keywords Context-aware • Location-based • Mobile app • Role-playing game • Story

8.1 Introduction

With mobile platform features such as portability, multimedia capacity, wireless Internet access, sensor technologies, and location-aware potential (Gil-Rodríguez and Rebaque-Rivas 2010; Kim and Schliesser 2007), mobile applications are widely used and bring opportunities to various application domains in our daily lives, including education, transportation, healthcare, tourism, and training.

While e-learning pedagogy is mainly compatible with the classroom paradigm, m-learning has made learning occur in the field (Laouris and Eteokleous 2005). With

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R. Huang et al. (eds.), *The New Development of Technology Enhanced Learning: Concept, Research and Best Practices*, Lecture Notes in Educational Technology,
DOI 10.1007/978-3-642-38291-8_8,

mobile devices' help, learning systems are capable of providing users immersive learning experiences in authentic learning environments. For instance, users can learn rainforest plants and ecology in the Amazon River zone of a botanic garden (Chang and Chang 2006; Chen et al. 2004; Kurti et al. 2007; Wu et al. 2008b). Mobile educational games further get users motivated while learning in museums and historical sites (Chang et al. 2008; Wu et al. 2010).

The research team of context-aware subproject of a 5-year renewable national research program in Canada, namely, the NSERC/iCORE/Xerox/Markin research chair program, proposed and designed a context-aware educational game-based mobile application in 2010, namely, CAMEG (Lu et al. 2010a, b, 2011a). The proposed mobile educational game can generate inquiry-based learning activities for users according to their needs (i.e., the course they take under formal learning situation and the knowledge they want to know more under informal learning situation) and the surrounding context. The usability of the game was confirmed (Lu et al. 2011b).

To make the generated learning activities more attractive to users, a new version of the game, namely, CAMRPG (Lu et al. 2011c), then was further designed and developed in 2011. The research team implemented a story generation engine based on narrative theory (Conle 2003; Mallon and Webb 2005; Ying et al. 2009). The generated stories were used for decorating the learning activities so students might feel that they live in the game world and role-play an actor, explore the game world, complete the quests, and learn something.

Two pilot studies had been conducted and questionnaires were designed and used to gather users' gaming and smartphone using experiences, computer game attitudes, acceptances toward the game, and perceived usability toward the game. The data had been collected and analyzed with quantitative analysis approaches that include independent *t*-test, regression, and path analysis for assessing various hypotheses. This chapter summarizes important findings and discussion. More detailed research methodology, results, and findings can be found in individual papers (Lu et al. 2011b, 2012a, b, 2014, in press).

8.2 Literature Review

Wu and colleagues argue that context-aware ubiquitous learning enables students to interact with learning objects in the real world with the supports from the digital world. They proposed an expert system which can provide students effective context-aware learning activities based on the domain knowledge (Wu et al. 2008a, 2013). Li et al. use students' ubiquitous learning logs to help them recall what they have learned via the automatically generated yes/no and multiple-choice quizzes (Li et al. 2013). With the help of analyzing the ubiquitous learning logs (including the location information), the researchers are able to detect whether the students are near to where they have visited and whether the places have learning logs of other students. Furthermore, the learning habits can be caught and used for making recommendation for the students to encourage them to learn. With the use of the expert system, students' cognitive abilities like analyzing and evaluating have been significantly improved. It is important for a mobile learning system being context aware; hence, the research team chooses to create an interesting context-aware mobile game for students learning domain knowledge.

There are many different game genres (ACMI 2013), and two of them seem to be rather suitable for educational purposes: adventure games and role-playing game (Frazer et al. 2008; Lu et al. 2011d). During the adventure journey of the gameplay in these games, players may encounter missions, tasks, and puzzles. The implicit knowledge or solutions for these quests require players' judgments and reactions. The challenges that a game gives to the players and the pleasure experiences that players gain from achievements in the game also motivate them to play the game continuously and foster their comprehensive understanding of domain knowledge.

A game without the story could not keep players even if it has shiny graphics. Parker and Lepper examine the effect of using fantasy context in teaching materials and find students having significant greater learning outcome than normal group (Parker and Lepper 1992). Dickey presents an overview of game genres and analyzes how important narrative is in educational game design (Dickey 2006). Rowe, McQuiggan, and Lester also find story is capable of pulling students into the plots and increasing their motivation for learning (Rowe et al. 2007). Some researchers also propose that the use of narrative design in the game gives players empathy toward the characters (i.e., have pity toward the victim character or feel responsible like a hero). The generated fun and empathy of games attract players to be involved constantly (Aylett et al. 2006).

Agent is a computer program which is capable of acting autonomously and learning continuously to meet its design objectives (Baylor 1999; McClure et al. 2013). In multi-agent system, many agents can work together to reach the system goal by satisfying users' needs (Leung et al. 2013; Weng et al. 2011). Balaji and Srinivasan summarize the benefits of multi-agent systems as follows (Balaji and Srinivasan 2010): (1) increased speed and efficiency because agents are working in parallel and asynchronously; (2) increased reliability and robustness since it is unlikely that all agents will fail at the same time; (3) increased scalability and flexibility since agents can be added at any time when needed; (4) reduced computational and communication costs due to the non-centralized architecture; and (5) high reusability because agents can be easily replaced or upgraded. Many other researchers have also applied the multi-agent concept to learning management and mobile educational system design and have reported good results in system scalability (Blair and Lin 2011; Dutchuk et al. 2009; Zhang and Lin 2007).

In summary, multi-agent-based architecture not only allows different agents to have different responsibilities but also provides an expandable way to develop further functions. For instance, new agents can be put into the game for special purpose, and old agents can be replaced with new and more functional ones. Multi-agent system design principles were adopted into the game design; hence, the game could run on different smartphones easily with the help of multiple agents (Lu et al. 2011a).

8.3 Game Design

8.3.1 *Learning Activity Generation*

Wu and colleagues propose a ubiquitous knowledge structure for museum learning and elementary-level botanic learning (Wu et al. 2008a). It has been proven to be a good way to store the knowledge, learning objects (in the real world) and materials (in the textbook), in one single knowledge structure. Its hierarchical structure is easy to understand and manage for general administrators (e.g., schoolteachers and system managers), and there is no specific rule for building a knowledge structure. In addition, a single structure can store knowledge associated with multiple domains/disciplines. Figure 8.1 shows the altered context-awareness knowledge structure.

Three layers of the ubiquitous knowledge structure were adopted to build the context-awareness knowledge structure of the authentic learning environment in which the mobile game takes place. The domain layer represents learning topics and domains that users are learning as well as the game themes that users can choose to play. The characteristic layer is a hierarchical structure in which the root nodes are associated with one or more nodes in the domain layer. The object layer stores all learning objects in the real world (e.g., rooms, equipment, pine trees, etc.) and in the virtual world (e.g., payroll system, business policy, electronic forms, etc.).

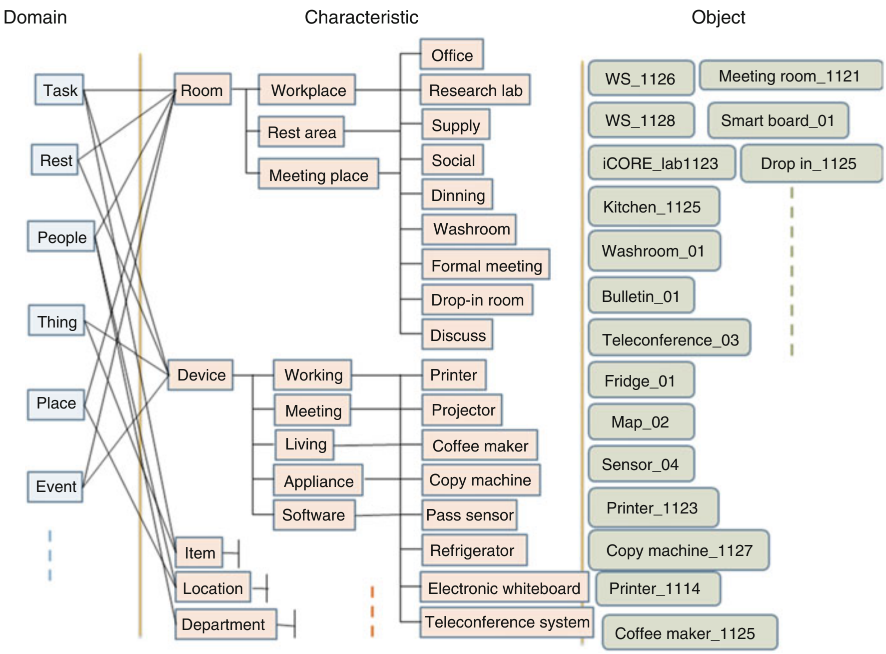

Fig. 8.1 Partial ubiquitous knowledge structure of an authentic learning environment

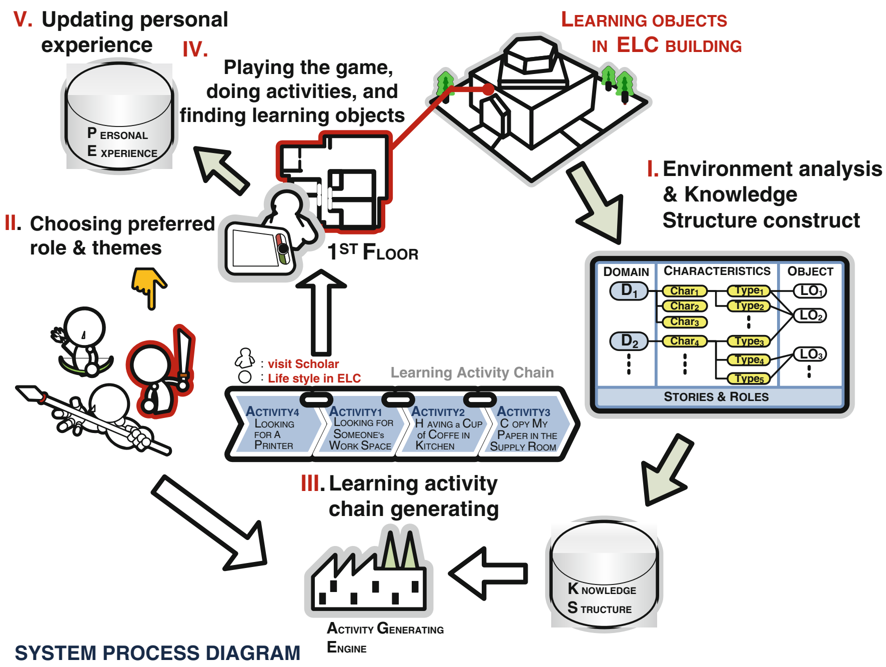

Fig. 8.2 Learning activity generation flow

Since the knowledge structure stores all learning objects and their attributes and embedded concepts, as well as the relationships among objects, an approach of retrieving relevant learning objects according to the user context, e.g., the chosen theme, location, and learning experiences, was developed. The learning objects retrieved via the approach can make users feel that the objects are what they want to see/know. Figure 8.2 shows the learning activity generation flow. More details of the learning activity generation mechanism can be found in Lu et al. (2011b).

8.3.2 *Multi-agent System*

Mobile phones have limited computing power and resources compared to desktop and laptop computers; the mobile applications hence are usually small and simplified. Tan and Kinshuk propose five design principles for developing applications on mobile devices (Tan and Kinshuk 2009): multiplatform adaptation, little resource usage, little human/device interaction, small data communication bandwidth use, and no additional hardware. The multi-agent-based system design approach is geared toward helping in complying with the abovementioned five design principles.

The multi-agent architecture was designed while implementing the mobile educational game in order to comply with the five design principles as well

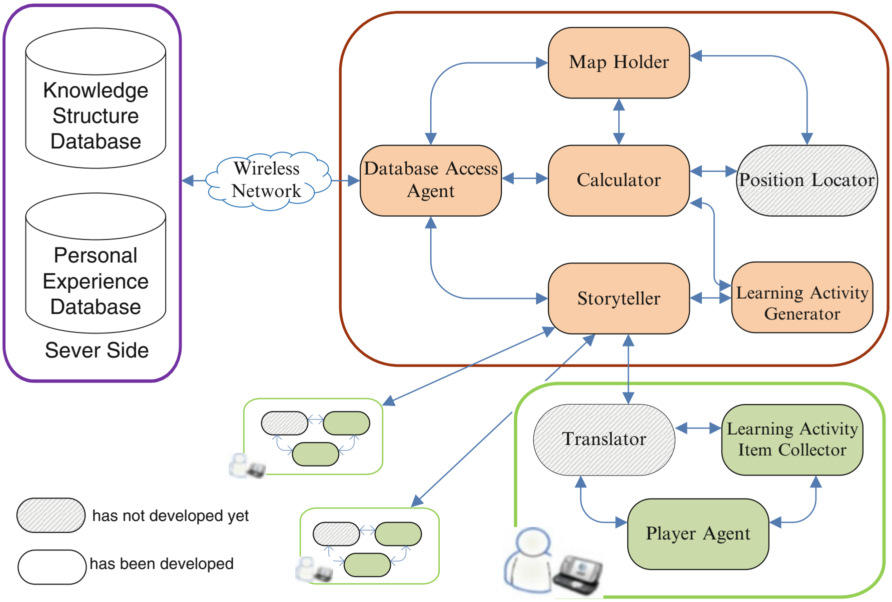

Fig. 8.3 Multi-agent architecture of the proposed mobile educational game

as to develop a lightweight, flexible, and scalable mobile education game. This architecture not only enables different agents to work on different tasks but also provides a way for easy improvements and maintenance of the game. For instance, we can put new agents into the game for special purpose and replace old agents with new and more functional ones. Figure 8.3 shows the multi-agent architecture of the proposed mobile educational game.

Two groups of agents reside on the user's mobile phone: three agents form a group to serve and interact with the user, namely, player agent, translator, and learning activity item collector, and six agents form a group to work out context awareness and the location-based learning activity chain, namely, learning activity generator, calculator, map holder, database (DB) access agent, storyteller, and position locator. The conceptual model illustrates the relationships among agents from the system's point of view. Each agent has its goal, task, demands, and communicated targets. More details for the responsibilities of each agent and the collaborations among agents can be found in Lu et al. (2011a).

8.3.3 Story Generation

Even the game can generate a series of learning activities for users, users may still be bored if they are just asked to do activities one by one. Story is important for designing an interesting and engaging game. Most of the popular games have

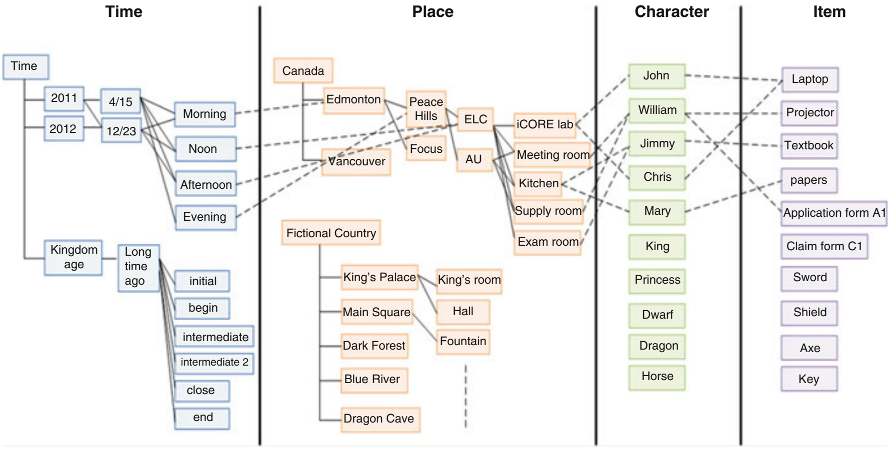

Fig. 8.4 Narrative knowledge structure

its background story no matter the story is a simple linear story (i.e., saving the princess) or a complex drama (i.e., the war happened between Alliance and Horde in World of Warcraft). Good story in the game design makes the game realistic and immersive as well as users involve constantly.

A story usually begins with putting one or more characters, in a kind of situations, in one of the settings in the game (Rabin 2010). The research team designs a narrative knowledge structure with core narrative elements identified from literature review as Fig. 8.4 shows. The structure can be used to store all necessary narrative elements for creating a story.

Each layer in the narrative knowledge structure is hierarchical form and has more than one level. The elements can be mixed of truth and fiction. Different schema is designed to store the properties of narrative elements and can be used for generating a story. A simple method is designed to pick up narrative data from the structure. The method is simple but still maintains the consistency of the two story fragments in the same storyline. More details of the story generation engine can be found in Lu et al. (2011c).

8.4 Pilots

8.4.1 Participants

Two pilots were conducted for gathering users' acceptance and perceived usability toward the game. Both pilots were conducted in the department of Information Management (IM), National Kaohsiung First University of Science and Technology (NKFUST), Taiwan.

The participants of the first pilot were 37 graduate students including 25 male and 12 female students who were just accepted by the master program. They were not familiar with the new environment (i.e., new school, new policy, new campus, and new faces) and qualified to the objective of the mobile educational game – "users can get familiar with the new working environment and learn new procedure and work flow by playing mobile educational game."

The participants of the second pilot were 55 undergraduate students including 31 males and 24 females recruited from students who enrolled management information system – an undergraduate course. In the pilot, teaching building E of the university was redesigned as a virtual science park where many famous IT business and company reside in for participants learning management information system concepts while playing the game.

All participants play the game with the smartphones prepared by researchers, as not all participants have smartphones and to avoid the influences that different devices may have in terms of affecting users' experiences in playing the game and perceptions toward the game.

8.4.2 Questionnaire

To gather users' gaming and smartphone using experiences as well as their perceptions toward the game in terms of acceptance and perceived usability of the game, questionnaire consists of demographic section, technology acceptance section (only second pilot's questionnaire has this section), and usability section that were designed and revised from questionnaires used and proposed by other researchers.

The demographic section collects participant's gender information, experiences of playing games, time spent in playing games, and experiences with smartphones.

The revised technology acceptance section has 31 five-point Likert scale items (ranging from 5 for "strongly agree" to 1 for "strongly disagree") to address four main constructs of technology acceptance model (Bourgonjon et al. 2010; Ibrahim 2011) (i.e., perceived ease of use, perceived usefulness, attitude toward using, and behavioral intention of using) and two game features (i.e., context awareness and story generation).

The revised usability section contains same 11 five-point Likert scale items for both pilots (5 for "strongly agree" to 1 for "strongly disagree") which may affect a system's usability in the three constructs described in ISO 9241-11 (ISO/IEC 1998; Lu et al. 2011b), i.e., effectiveness, efficiency, and satisfaction.

8.4.3 Reliability and Validity of Questionnaire

Although the questionnaire was adopted from previous research results and its validity and reliability had been proven, the research team assessed the reliability and validity of questionnaire with the collected data once again before applying quantitative analysis approaches to verify given hypotheses.

The Cronbach's alpha values of the revised usability section are 0.840 for first pilot and 0.873 for second pilot indicating that the items can be seen as reliable due to its internal consistency is good enough (i.e., exceeds 0.75) (Hair et al. 1995). Furthermore, the Cronbach's alpha value of the revised technology acceptance section for the second pilot is 0.826, also indicating the items are reliable.

On the other hand, with the help of principal component analysis, some items with lower factor loading were identified and removed. The removal of those items improved the Cronbach's alpha values; therefore, the remaining items were still capable of representing the correspondent constructs, respectively.

8.5 Findings and Discussion

8.5.1 Perceptions of Female Users Are More Positive

Although both male and female participants perceived the usability of the game positively, female participants' responses to all factors were relatively higher than male participants in both studies. Many researchers also found that male participants tend to feel the educational games are boring, while their counterpart (i.e., female participants) has more positive perceptions toward the educational games (Gwee et al. 2010; Law 2010). One possible reason of having this finding is that female participants are more likely than male participants in terms of using mobile phones (Chiu et al. 2013). More detailed data collected, data analysis approaches, and results and findings can be found in Lu et al. (2011b, 2014).

8.5.2 Story Helps Male Users Perceive Effectiveness and Satisfy the Game

The game in the second pilot has built-in story generation engine. The participants of the second pilot, hence, see a generated story fragment for the learning activity they take. The result shows that the participants of the second pilot perceive higher effectiveness and are more satisfied with the game than their counterpart – the participants of the first pilot. Without story's help, the game is more like a game that participants are familiar with in the real world. Therefore, they are more satisfied with it than the version without story.

Moreover, the result of independent *t*-test for examining the difference between male and female participants of the first pilot shows that the male and female participants are significantly different in terms of satisfaction with the game they played. However, there is no significant difference on the perceived satisfaction toward the game among male and female participants of the second pilot. This finding implies that the stories may make male participants feel the game more like a real game and make them have higher satisfaction toward the game.

More detailed data collected, data analysis approaches, and results and findings can be found in Lu et al. (2012b, 2014, in press).

8.5.3 Having No Experience of Using Smartphone Doesn't Affect Perceived Usability Toward the Game

The result shows no significant difference between participants who have experience of using smartphone and those who don't. Therefore, experience of using smartphone does not affect participants' perceived usability of the game. The reason of having such finding may be caused by the ease of user interface and intuitive way of collecting quest items in the real world – users only need to use the built-in camera to scan the QR code tag attached to the real-world objects, and the system will proceed to the next stage without user intervention. This finding suggests that there is no need to worry about whether or not a user has used a smartphone while designing and deploying such context-aware mobile role-playing game for learning. More detailed data collected, data analysis approaches, and results and findings can be found in Lu et al. (2014).

8.5.4 Only Attitude Toward Computer Games and Comfortableness to Computer Games Affect Users' Voluntariness of Using the Game

The independent *t*-test result shows that male participants like computer games much more than female participants as well as have higher confidence in playing computer games. However, having confidence in playing computer games and liking computer games in fact have no influence on participants' voluntariness of using the proposed game. The result shows that only attitude toward computer games and comfortableness to computer games make participants have significant different voluntariness of using the game and similar games for learning in the future.

As the proposed game is not quite like commercial computer games and has simple and intuitive user interface compared to commercial ones that participants always see, they may be more comfortable in trying the proposed game. Moreover, as the content of the game is learning oriented instead of defeating monsters or solving difficult mystery like a commercial game usually asks them to do in the gameplay, they may have higher confidence in playing the proposed game. Under such circumstance, having confidence in playing computer games and liking computer games become not an issue to affect participants' voluntariness of using the game. Therefore, only participants' attitude toward computer games and whether or not they feel comfortable to computer games influence their voluntariness of using such kind of games in learning.

The finding implies that users are willing to use mobile educational games for learning as long as they feel comfortable to computer games and they are positive to computer games. In other words, mobile educational games are also welcome by female users. This finding proves that games can be equally effective and motivating for both male and female students (Ke 2008; Papastergiou 2009) and makes us be aware of how positive perception toward the use of game-based learning solutions that female participants have. It is not like what most of us thought and were afraid of before – "male participants love educational games much more than female and female students may not want to give the educational games a shot."

More detailed data collected, data analysis approaches, and results and findings can be found in Lu et al. (2012a).

8.5.5 Hard-Core Players Treat the Game as a Real Game

According to the demographic information of the participants, hard-core game players spend an average of almost ten times of the hours on playing computer games than casual game players. Since hard-core game players play more games and more often, it may lead us to have an assumption that they have a higher standard while evaluating games they play than casual game players. The result shows that hard-core game players hive higher acceptance toward the game than casual game players. One possible reason is "hard-core players like game and would like to give any game a shot." However, as the data was collected after the gameplay, therefore, this finding implies the hard-core players treat the game as a real game instead of a "learning application." More detailed data collected, data analysis approaches, and results and findings can be found in Lu et al. (in press).

8.6 Conclusion

This chapter first reveals the design of personalized context-aware mobile learning activity generation and transition story generation. Two pilots have been done for assessing the proposed game, and the collected data has been analyzed with quantitative approaches. The proposed game is well designed and is considered as a real game by hard-core players. No matter what users have experience in using smartphone, they appreciate the usability of the game. On the other hand, the game is easy to learn and easy to use for users who don't have experience in using smartphone.

Some interesting and important findings have been found. For instance, as long as users feel comfortable to computer games or they are positive to computer games, they will be voluntary in using such kind of mobile games for learning, and their gender doesn't matter. In such case, educational game developers could be encouraged by putting more efforts on designing high-quality games with simple and intuitive user interface and gaming features such as the adoption of two-dimensional code scanner with built-in camera. Also, this research finds that story plays a very important role in terms of making male users perceive the effectiveness of the game and be more satisfied with the game. Therefore, the educational game developers should pay more attention on the story creation and the connection between learning activities and decoration stories. So the effectiveness of their games can be well perceived.

Acknowledgments The authors wish to thank the support of NSERC, iCORE, Xerox, and the research-related gift funding provided to the Learning Communities Project by Mr. Allan Markin.

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Chapter 9
Development and Evaluation of an Ontology Based Navigation Tool with Learning Objects for Educational Purposes

Arif Altun and Galip Kaya

Abstract Learning objects offer a new content design methodology for instructional designers in developing and utilizing e-learning environments. These learning objects are usually tagged and stored in repositories in a taxonomic way and mostly accompanied by key-based searching capability. Since those repositories do not have complicated reasoning and inference capabilities, access to and integration of them into an existing course package create a problem for e-learning instructors and learners. These problems will be able to be fixed by integration of semantic web technologies, and current learning object repositories could better be utilized by developing ontology-based learning object retrieval tools. In this chapter, the development and evaluation of an ontology-based learning object navigation and retrieval tool (OBELON) is presented. As part of an evaluation process, OBELON was compared with a taxonomy-based learning object retrieval system by using two information retrieval parameters: precision and recall. The findings indicated that ontology-based system produced more precise and high recall scores.

Keywords Learning object • Ontology • CogSkillNet • Ontology evaluation • Instructional design

9.1 Introduction

Importance of adaptive and personalized learning environments is increasing due to the growing use of semantic web technologies in education. Interaction of learner and the learning object repositories may be considered as the first step of finding an appropriate content for the learner and delivering a personalized environment

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R. Huang et al. (eds.), *The New Development of Technology Enhanced Learning: Concept, Research and Best Practices*, Lecture Notes in Educational Technology, DOI 10.1007/978-3-642-38291-8_9,

to the learner. In the next step of the personalization, learning environment shall provide learners a framework to prepare adaptive learning contents due to learners' individual differences including their cognitive differences.

Researchers concentrate on combining ontologies and learning object repositories to develop semantic repositories and semantic navigation tools. Learning objects (LOs) are based on object-oriented programming. They can be achieved digitally over the Internet, and they are computer-based teaching components (Wiley 2000). Packaging and storing LOs in repositories in harmony with SCORM standards also facilitate software agents to retrieve LOs that are appropriate to the needs of learners. Thus, incorporating semantic web technologies and software agents together, course contents could also be created automatically.

Yet, the use of learning object repositories including semantic web tools in learning processes is either very limited or not geared toward educational purposes. At this point, ontology-based navigation tools are thought to contribute to the design and delivery of learning objects within the education domain. In this chapter, first, the development of an ontology-based learning object navigation tool (OBELON) will be described. This tool is based on CogSkillNet (ontology for cognitive skills) developed by Aşkar and Altun (2009). CogSkillNet provides learners an adaptive content by accessing learning objects based on tagged cognitive skills. Selection of this cognitive skill ontology has three main reasons: First of all, as cognitive skills have a domain-independent terminology, there is a high chance to interoperate with other ontologies. Secondly, cognitive skill ontology can scaffold teachers during the process of creation and evaluation of learning contents as a learning path creator tool. Lastly, in the field of education, cognitive skills are represented in a taxonomic way. Such novel use of ontologies will both increase the awareness about cognitive skills and revisit the representation of relations among cognitive skills for teachers in educational environments.

In the next section, first, the use of ontologies in education and adaptation of semantic web technologies to learning and teaching process will be summarized. Second, examples for using ontologies in e-learning environments will be reviewed and synthesized.

9.1.1 Ontology Use in Educational Settings

Ontologies are attracting instructional designers' and educators' attention for various reasons. First of all, by developing and/or using an ontology, educators get a chance to observe and to share a common understanding of the structure of information among people and/or software agents as suggested by Musen (1992) and Gruber (1993). Since the interconnectedness between learning standards and teaching practices is gaining importance and more quality assurance systems are being developed, by utilizing an ontology, digital learning platforms (such as MOOCs and other LMSs) will be a junction for other e-learning components in the network.

Secondly, simply having a domain ontology will enable the reuse of domain knowledge. For example, each student will be able to access interrelated domains as well as a single domain through semantic relations. Therefore, navigation among the concepts will not be limited to a single domain area.

Thirdly, separating the domain knowledge from the operational knowledge is another common use of ontologies (McGuinness and Wright 1998). We can describe an expectation (or standard) in the learning space and implement a learning space independent from the expectations through learning processes and concepts. Finally, while developing a domain ontology, terms and their specifications are analyzed, which is extremely valuable when both attempting to reuse existing ontologies and extending them (McGuiness et al. 2000). Boyce and Pahl (2007) stated the importance of using ontologies in teaching design and creating course contents and advocated that as there are many ontologies in different subject matters, the use of ontologies is not clear yet within education context, and there are no suitable ontologies covering multiple subjects. In their research, they proposed an ontology development methodology, further stating that this methodology is more suitable for domain experts to create course contents. Consequently, this paves the way for evaluating the existing curriculum and for developing more personal and remedial programs for individual users.

Research in ontology use and its applications in educational settings can be summarized in three broad categories:

1. Access to content, which refers to providing a navigational support and fast and accurate access to the relevant content
2. Content aggregation, which refers to developing automatic and/or semiautomatic course packages
3. Personalization, which covers search engines for varying personal characteristics, providing personalized learning environment and suggesting personalized content

In the following section, literature is reviewed based on these three categories. One of the earlier initiatives of using ontology in educational context was introduced by Fok (2006). In this ontology called PEOnto, the purpose was stated to develop a personalized educational ontology by providing an access to learning objects through ontology for the needs of learners.

In another ontology, Askar et al. (2008) proposed POLEONTO ontology that is developed for e-learning environments. They illustrated the use of POLEONTO for K-12 education ontology in an e-learning environment. In POLEONTO context, the authors separated the learning processes and concepts in defining an expectation or a standard. Learning processes were defined as a set of skills, which were embedded in the curriculum and requested by instructors. In the POLEONTO context, skill is defined as the interaction and any processes between persons and concepts, whereas concepts were defined as the solid knowledge articulated across the curriculum. As a conclusion, since POLEONTO is based on concept and skill ontologies leading to expectations, the authors suggested that it is aimed to be applicable to different curricula in various institutions, such as in Higher Education and Corporate Training settings.

In an ontology reuse research, which could also be considered as content aggregation process, Ming Che et al. (2007) has used an e-learning ontology to solve problems about interoperability and reusability. The algorithm used in research is able to classify learning objects due to concepts by inferring on domain ontologies developed by system domain experts. System is evaluated in Java domain ontology. According to experimental results, researchers claimed that ontology-based system increases precision in the classification of learning objects and resolves semantic complexities.

According to Kontopoulos et al. (2008), automatic content creation was crucial in developing educational software and defended that semantic web technologies can handle this situation. Their system named PASER was a mere curriculum generator using ontologies, semantic web technologies, and artificial intelligence. PASER would represent information by using ontologies with the capability of reasoning for content creation. They further showed that it was possible to retrieve educational materials by using ontologies to reach educational goals and automatize the content creation. Consequently, researchers underlined the fact that more research was needed in the field of automatic content creation to make individualized content creation possible for learners.

Jovanović et al. (2007) introduced a conceptual model for learning objects: learning object context model. The use of an ontology based on their model enables explicit representation of learning object metadata. Researchers also underlined that this model can be interoperated with other learning ontologies and create a relationship between learning design and learning objects. The researchers based their model on IMS-LD knowledge model and introduced the concept of basic building blocks of learning design. Finally, the model was transformed into a web-based environment based on two ontology-based frameworks: LOCO analyst and TANGRAM.

Lemnitzer et al. (2008) had developed LT4EL system to enable access to learning materials prepared in different languages with a capability of combining them in learning management systems. In their system, the researchers made the learning objects to be mapped onto concepts with ontologies in order to enable semantic searches. By the help of domain ontology, their system enables to access learning objects that are created in up to eight different languages. Mapping words in different languages was provided based on WordNet infrastructure. Finally, this system was evaluated by word-based and semantic-based searches in all languages, and the results were calculated by F scores. It is concluded that LT4EL system provided better results in all languages.

9.2 Methodology

9.2.1 Learning Objects: Design and Development

Learning objects (LOs) were designed and developed as a 14-week-long course requirement by senior undergraduate-level teacher trainees attending the department of computer education and instructional technologies at Hacettepe University. First of all, they were instructed about the nature and functions of the learning objects within the field of instructional design. Secondly, they were trained about the technical details and standards in learning object packaging. Finally, they were presented the content in three tiers: (a) the nature of the cognitive skills; (b) content design principles, including the presentation strategies; and (c) authoring the content. The nature of the cognitive skills included the definition and their ontological representations in CogSkillNet. The content design process included screen design, presentation strategies, and navigation design within each learning object. For authoring the content, they were provided options to choose from, including basic HTML to authoring tools, such as Flash or quiz maker software.

For presentation strategy, the teacher trainees were provided a common framework, which included an INTRODUCTION, TUTORIAL, PRACTICE, QUIZ, and SUMMARY. Therefore, each LO was packaged with this presentation scheme.

The learning objects were packaged by the teacher trainees themselves. This process was explained to them in a lecture and practiced in a lab study. As a content packaging tool, RELOAD packaging software was used. Each package was checked with its completeness with the SCORM metadata standards.

9.2.2 OBELON: Design and Development

OBELON as a navigation tool is developed by using Java (www.java.com) programming language in Eclipse software development environment. As the navigation tool is a web-based environment, user interface is designed by Vaadin (www.vaadin.com) framework that provides an accessible infrastructure for web-based Java applications. Jena (http://jena.sourceforge.net/) semantic web framework is used for ontological queries. Jena is a Java-based library that provides SPARQL-based queries for RDF- and OWL-based ontologies. Ontology and learning object relationships are saved to ontology by using Jena-TDB (http://www.openjena.org/TDB/) database. The UML class diagram is presented in Fig. 9.1.

The application is started by LOOntoApplication. The initial homepage is called from LOTabSheet class, which presents LOListSheet, LOAddSheet, and LOQuerySheet as a tabbed menu. Two of the menus (listing the LOs by LOListSheet and query by LOQuerySheet) are available for general users, but authentication is needed to be able to access the link to add more learning objects (by LOAddSheet). General users would not be able to access this link, which is called from OntologyTabSheet. The general GUI of the application is presented in Fig. 9.2.

LOListSheet lists the skills, the relations between skills, and the learning objects associated with these relations represented in CogSkillNet ontology. The user observes the LOs according to their presentation strategy. When needed, each LO is called either by clicking on the link or the play button on its left. In addition, users

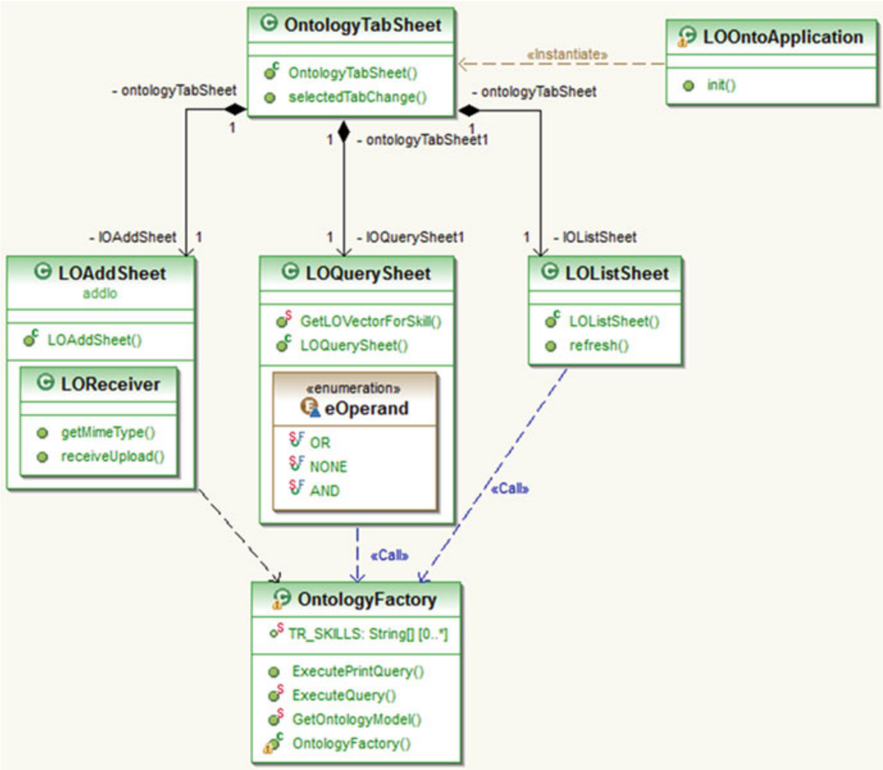

Fig. 9.1 General class diagram of the application

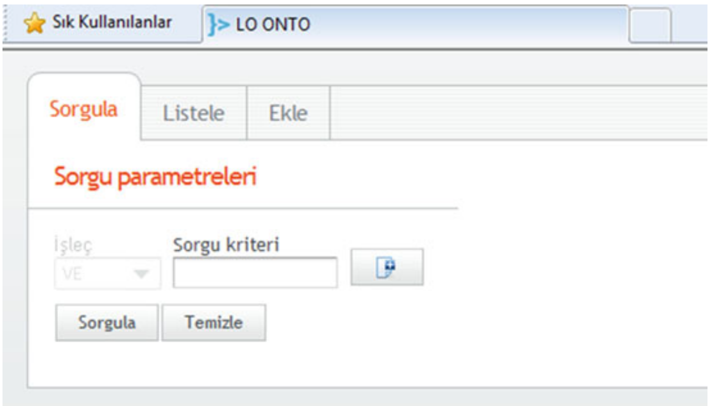

Fig. 9.2 GUI of the application

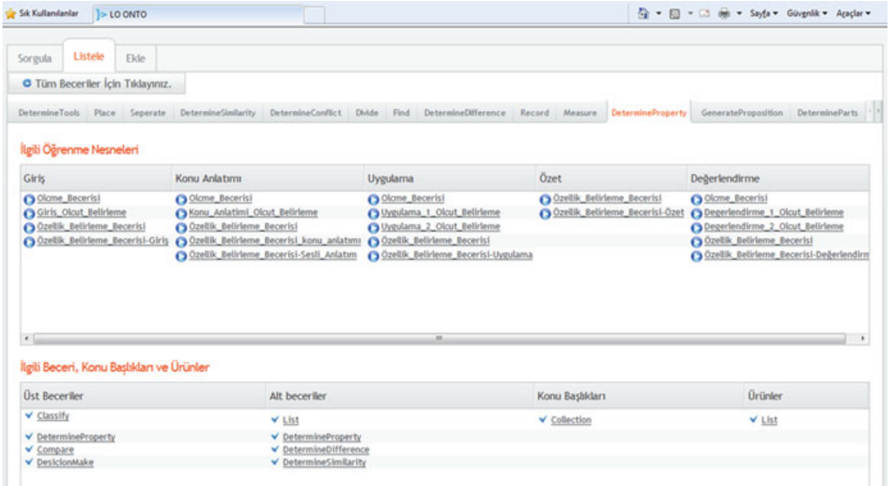

Fig. 9.3 Skills and LO listing page (LOListSheet)

are provided sub- or upper skills, the content headings for these LOs, and other related LOs (see Fig. 9.3).

LOListSheet calls SkillsNavigationPanel for navigation among the skills and LOs. SkillsNavigationPanel lists the skills, content headings, and related LOs by using SkillPanel class. LOPanel class, on the other hand, lists the related LOs of the selected LO. The detailed UML diagram for the LOListSheet is presented in Fig. 9.4. For the sake of readability, only the description and the detailed UML diagrams will be provided for the other classes.

LOAddSheet enables the authenticated users to add more LOs and make the relations between LOs and the existing cognitive skills. The metadata of uploaded LOs were parsed, and the cognitive skills declared in the metadata for each LO were found automatically. Those cognitive skills were stored in the database, and its relations were established with the confirmation of the user (see Fig. 9.5 for a sample interface view for LOAddSheet).

LOReceiver is used when uploading the LO to the system. The relationship between the LO and the cognitive skills is maintained with this class. In order to create LearningObject object, the necessary information is gathered from the user by using the LOAttributesForm class. The detailed UML diagram for LOAddSheet class is presented in Fig. 9.6.

LOQuerySheet presents an interface for simple and/or Boolean queries. Queries are executed either on LOs or on cognitive skills. The so-called LOs are listed below the table and could be explored more in depth by hyperlinks, in which once clicked, users could access to the related LOs by calling the class of RelatedLOWindow. The detailed UML of LOQuerySheet is presented in Fig. 9.7.

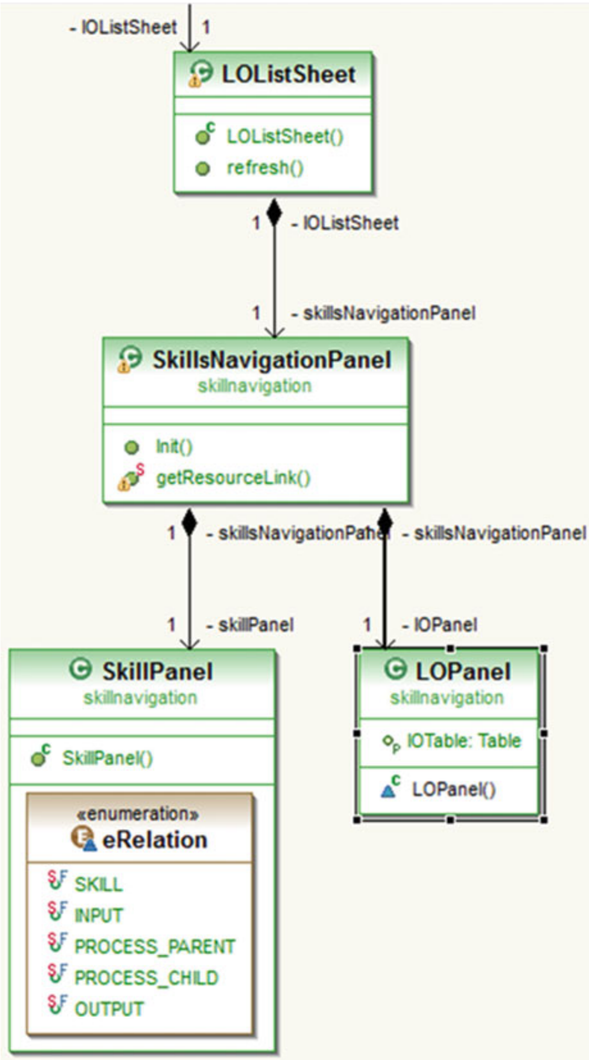

Fig. 9.4 Detailed class diagram for LOListSheet

OntologyFactory is the base class upon which other classes use when adding new LOs, running queries upon ontology, etc. Taking SPARQL queries into account, this class passes the results to the related classes. If there is no prior ontology database, OntologyFactory class creates that database by using the OntModel in the Jena library. The ontology model, on the other hand, is created by TDBFactory class in the Jena.tdb package. Thus, the Jena-TDB library makes the processes remain persistent within ontology. The detailed class diagram for OntologyFactory is presented in Fig. 9.8.

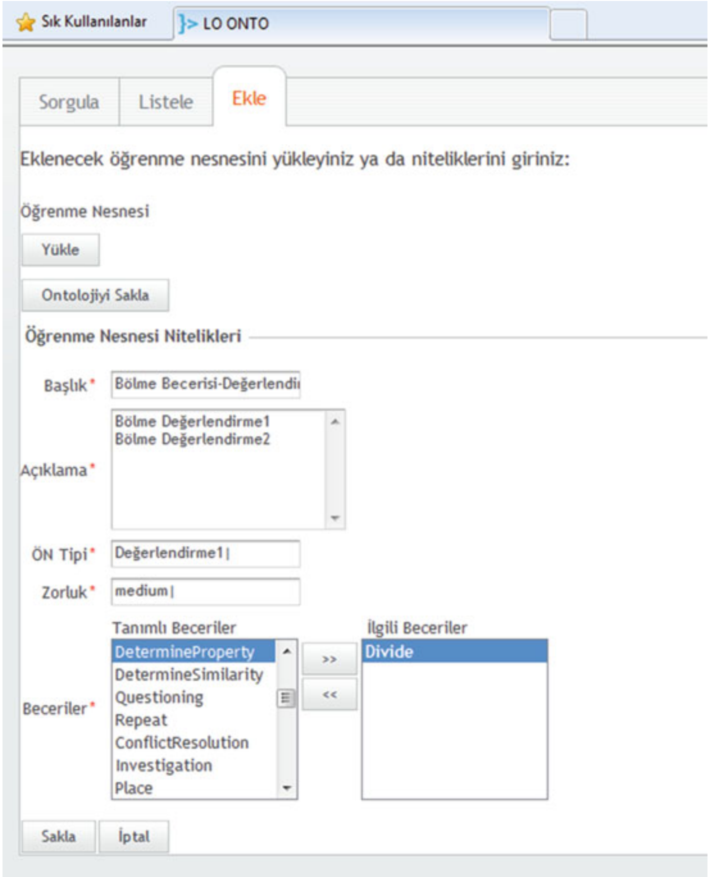

Fig. 9.5 GUI for uploading LOs (LOAddSheet)

9.2.3 Comparison Tasks

To compare the system performance to keyword-based performance, three main tasks are determined and these tasks are presented below:

1. Task 1: Find learning objects for "determine tool" and "place" skills which have a presentation strategy of "TUTORIAL."
2. Task 2: Find cognitive skills that can be a subskill for "determine property."
3. Task 3: Find cognitive skills that contain the cognitive skill "classify."

When these tasks were executed in each environment, the data log was kept for analysis. These data included the numbers of retrieved document, total document count, retrieved relevant document count, and total relevant document count for each task.

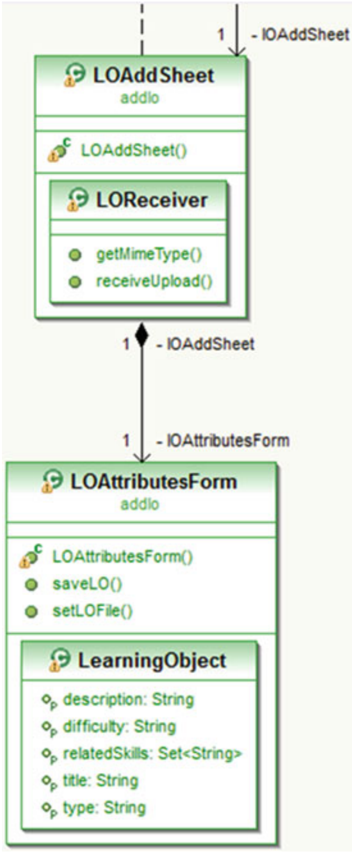

Fig. 9.6 Detailed class diagram for LOAddSheet

9.2.4 Effectiveness Analysis

In evaluating the effectiveness of OBELON, precision, recall parameters, and *F* scores (harmonic mean of these parameters) are calculated. These parameters are used in the evaluation of ontologies (e.g., Khan et al. 2004; Nagypal 2005; Shehata et al. 2007, Lemnitzer et al. 2008) and discussed in detail in Kaya and Altun (2011). Precision is the rate of retrieved document count to total document count (1), and recall is the rate of retrieved relevant document count to total relevant document count either retrieved or cannot be retrieved (2). *F* score is harmonic mean of precision and recall values (3). As this method is applied to learning objects, the counts of the retrieved learning objects are used:

$$(1)\ \ \text{Precision} = \frac{\#\,(\text{retrieved relevant document count})}{\#\,(\text{retrieved document count})}$$

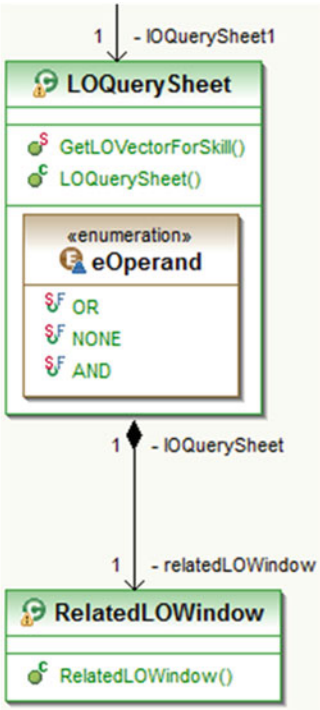

Fig. 9.7 Detailed class diagram for LOQuerySheet

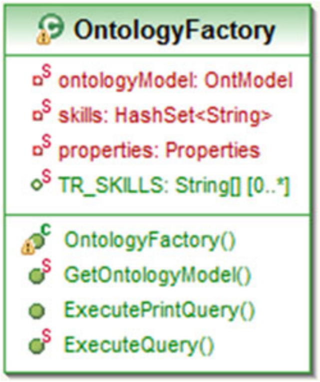

Fig. 9.8 Detailed class diagram for OntologyFactory

$$(2)\ \ \text{Recall} = \frac{\#\,(\text{retrieved relevant document count})}{\#\,(\text{total relevant document count})}$$

$$(3)\ \ F = \frac{2 * P * R}{P + R}$$

9.3 Findings and Evaluation

This section will include the results for recall, precision, and F scores. As a category-based learning object retrieval tool, Moodle (www.moodle.org) is selected because it is used over 70,000 sites (www.moodle.org/stats), is an open-source software, and is capable of running SCORM compatible learning objects. A new course is created in Moodle with similar learning objects as in OBELON. All skills are listed with unique titles and content is presented as including all presentation strategies together.

When comparing the system performance to Moodle, three main tasks were executed. Since the data were analyzed according to these tasks, in the next section, the findings will be presented for each task separately.

9.3.1 Task 1: Find Learning Objects for "Determine Tool" and "Place" Skills Which Have a Presentation Strategy of "TUTORIAL"

In this task, user is requested to find learning objects about the two selected cognitive skills. The learning objects shall also have presentation strategy of subject lecture. There is a total of eight learning objects in learning object repository about this task: Four of them were related to "determine tool" and the other four were to "place."

At the end of this task, navigation tool retrieved all the related learning objects in repository and additional other learning objects that are related to the given skills. As a result, recall value is calculated as 1 for navigation tool in this task. Moodle is able to retrieve six of the learning objects that should be retrieved and additional of many unrelated learning objects with presentation strategy or skills. The results of task 1 are given in Table 9.1.

9.3.2 Task 2: Find Cognitive Skills That Can Be a Substructure for "Determine Property" Skill

In this task, user is asked for finding substructure skills of "determine property" skill. At the end of this task, user should retrieve the following cognitive skills: list, determine property, determine difference, and determine similarity. The navigation

Table 9.1 Results of task 1

		Retrieved relevant LO	Retrieved total LO	Total relevant LO	Precision	Recall	F score
Task 1	Moodle	6	80[a]	8	0.075	0.75	0.136
	Navigation tool	8	26	8	0.307	1	0.469

[a]Eight documents retrieved by Moodle search are omitted

Table 9.2 Results of task 2

		Retrieved relevant LO	Retrieved total LO	Total relevant LO	Precision	Recall	F score
Task 2	Moodle	2	6[a]	4	0.333	0.5	0.399
	Navigation tool	4	7[b]	4	0.571	1	0.726

[a]Four documents except learning objects retrieved by Moodle search are omitted
[b]Repetitive skills are omitted

Table 9.3 Results of task 3

		Retrieved relevant LO	Retrieved total LO	Total relevant LO	Precision	Recall	F score
Task 3	Moodle	0	8	2	0	0	–
	Navigation tool	2	6[a]	2	0.333	1	0.499

[a]Repetitive skills are omitted

tool retrieves all skills and additionally retrieves top skills of "determine property" skill. On the other hand, in Moodle searches, two relevant skills and some of other skills are retrieved. The results of task 2 are given in Table 9.2.

9.3.3 Task 3: Find Cognitive Skills That Contain Classify Skill

In this task, top skills of classify skills were to be retrieved. At the end of this task, user should retrieve filter and evaluation as cognitive skills. By using the navigation tool, both of the required skills and additionally subskills of determine property skills are retrieved. In Moodle 3 words are used to search and six to 11 skills (with the mean score of eight) are retrieved, but none of these are relevant to required skills. The results of task 3 are given in Table 9.3.

As a conclusion, all the results indicated that ontology-based navigation has an advantage over keyword search. The users not only access the required content but also access other related learning objects with declared metadata, including their presentation strategies or other related cognitive skills. Meanwhile, it should be noted that this study is not intended to compare Moodle with another tool, at all. It simply uses the search option in Moodle as a popular LMS and uses the taxonomy-based and keyword-enabled values as data to compare with ontology-based access to the content.

9.4 Conclusion and Discussion

In this chapter, we aimed to describe and discuss the development and evaluation of a navigational tool (OBELON) based on a cognitive skill ontology (CogSkillNet). The results of ontology-based navigation tool are compared to a category-based navigational one in terms of precision, recall values, and F scores.

The performance of ontology-based navigation tool is found to be better than category-based navigation based on their precision and recall values. In addition, it is observed that OBELON as a tool can be used to create a learning environment based on learner profiles (e.g., utilizing presentation strategy). As put forth in this chapter, when learning objects are pieced together, a learning object retrieval system can be created, and with the support of ontology infrastructure, a personalized learning environment is presented to learners.

In addition to providing a personalized learning environment to learners, this system is able to support instructors to retrieve and combine learning objects in different learning object repositories in a fast, easy, and intelligent way to create course contents according to learners' cognitive profiles. Thus, instructors and learners with no technical information about how learning objects operate are able to create learning contents of any course or subject easily by accessing learning object repositories.

To deliver the content, presentation strategy is used as a user model in this study. Learning objects are tagged to represent related presentation strategy with their relation to learning objects; hence, ontology is created in this way. To provide access to learning content, correlated learning objects are presented to users in tables. Similarly, cognitive and/or noncognitive attributes (e.g., attention level, memory capacity, learning style, etc.) can be used to interact with ontology.

In this chapter, it was described how learning objects are created and packaged by preservice teachers according to teaching design principles. However, it should be emphasized that packaging process is as important as the design of the content. Especially, in ontology-based learning environments, providing packaging standards of learning objects and creating connections of ontology and learning objects are both crucial. In future, interoperability of cognitive skill ontology with different ontologies (e.g., mathematics, physics or cognitive styles, etc.) shall be tested. Also, with the use of automatic and semiautomatic ontology creation tools, testing the interaction of cognitive skill ontology with larger repositories is planned.

Finally, more research about how these learning environments could address individual differences and provide guidance to learners in their learning process is needed. More specifically, researchers could explore (a) disorientation and disorientation perception in navigation process in ontology-enabled environments, (b) to what extent realization of learning happens and how ontology affects the longitudinal performance, and (c) how would learners perceive their learning experiences in such technology-enhanced environments.

Acknowledgments This research is supported by the Scientific and Technological Research Council of Turkey (TUBITAK)-SOBAG, with the grant number of 110K602.

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Part III
The Best Practice of TEL

Chapter 10
Practicing Collaboration Skills Through Role-Play Activities in a 3D Virtual World

Valentina Caruso, Anders I. Mørch, Ingvill Thomassen, Melissa Hartley, and Barbara Ludlow

Abstract In this chapter we report on the preliminary findings of a case study using the 3D virtual world Second Life in a preservice teacher distance education program. We focus our analysis on role-playing and collaboration, the two central aspects of social learning that we hypothesize this online learning environment is well equipped to support. We examined two sections of a graduate-level special education teacher preparation course where 34 students participated in online learning activities, using Second Life as the primary educational platform. The results, based on qualitative analysis, showed that the sense of unselfconscious presence created through avatars and the immersion created by the 3D environment allowed learners to be engaged more effectively in practicing collaboration skills of a certain complexity (modeled after challenging classroom situations). Our data also indicate that synchronous online learning environments, represented by Second Life in our case, present great opportunities for combining traditional pedagogical approaches and virtual world pedagogy in order to overcome barriers between educational theory and pedagogical practice in teacher education programs.

Keywords Case study • 3D virtual world • Role-play • Interaction analysis • Sociocultural approach • Teacher education • Special needs education

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R. Huang et al. (eds.), *The New Development of Technology Enhanced Learning: Concept, Research and Best Practices*, Lecture Notes in Educational Technology,
DOI 10.1007/978-3-642-38291-8_10,

10.1 Introduction

Teacher education programs often have difficulties integrating pedagogical theory and practice (Muir et al. 2013; Reynolds-Keefer 2013). Particularly, many preservice teachers find it challenging to develop professional skills in order to manage classrooms and student behavior (Reynolds-Keefer 2013; Simonsen et al. 2013). In this chapter, we investigate teaching of theoretical concepts conducted through distance education and role-play as an alternative to a conventional classroom setting. 3D virtual worlds and Second Life seem particularly well suited for this purpose, as these environments provide a platform for social learning activities, e.g., social interaction, collaboration, and role-play (Vasileiou and Paraskeva 2010; Masters and Gregory 2012; Muir et al. 2013). However, the literature relating to the use of Second Life in teacher education is largely vague and limited.

To that end, we have studied a teacher education course designed for special needs educators organized at a North American University as part of a distance education program. We make use of a sociocultural perspective on learning for data selection and analysis. The sociocultural perspective emphasizes the social aspects of learning as prerequisite to individual learning, such as interaction among students, between students and teachers, and the effects of role-play and artifact mediation, including ICT-based tools. The general aim is to explore the potential of Second Life as an educational platform for distance education and social learning in special education and to contribute to the discussion on the platform's future use in education in general.

We have used qualitative methods as part of a case study, and the findings from our study indicate that the interactive nature of Second Life fosters social interaction and collaboration among its participants by means of role-playing activities. When represented by avatars, the learners seemed confident and engaged in their role-playing activities, and they were able to apply the theoretical concepts taught in the course in practical role-play activities modeled after challenging classroom situations.

10.2 A Sociocultural Perspective on Teaching and Learning in Virtual Worlds

Previous research argues that both social and individual aspects are important to learning (Salomon and Perkins 1998). We have adopted a sociocultural perspective for our analysis, as it provides concepts that can help us identify the multiple contexts of learning. Christonasi and Plakitsi presented several sociocultural features with particular reference to Vygotsky's (1978) theory for studying social interaction in Second Life, emphasizing the need to define and understand the relationship between learners' self-presentation, roles in a group, and cultural artifacts used to practice teaching skills by means of virtual role-playing activities.

According to Vygotsky (1978), signs and artifacts mediate human activity. Signs are connected to language and other symbol systems (e.g., diagrammatic notations), and artifacts are the concrete tools used by people in order to carry out their everyday activities as well as the outcome of the activity. One can think of the difference between the two as abstract and concrete tools. From a sociocultural perspective, they play a central role as "mediating artifacts," mediating interactions between human actors, between human actors and other artifacts, and with oneself (Wertsch 2007). In addition to mediation, the sociocultural context is another central component in sociocultural studies. This implies that these components have implications for learning and should be taken into account during analysis. For example, the sociocultural context influences our choice in tools, which again brings changes in mediated actions, a reciprocal relationship that may involve social, cultural, and institutional dimensions (Ludvigsen and Mørch 2010; Mifsud and Mørch 2010; Mørch 2013; Säljö 2010).

Second Life is a virtual world, but it is situated in the real world of its users. Researchers should be cognizant of the multiple influences (both virtual and real) that may impact learning in positive or negative directions. Therefore, we believe that in Second Life, interaction and role-play, the two means of achieving social learning and collaboration, must be located socially, culturally, and institutionally. Mediating artifacts play a central role in this process and can help us analyze to what extent educational purposes have been achieved and what new collaboration skills have been developed.

Related to the concept of mediation is the notion of zone of proximal development (ZPD). ZPD is arguably Vygotsky's most famous concept, as it continues to be cited long after it was first proposed, and there are numerous applications to instructional design. For Vygotsky, it provided a link between social learning and individual development (Vygotsky 1978). Metaphorically speaking, it pinpoints what can be called "buds of knowledge," which refers to nascent knowledge that we all possess, distributed in space and time by a "distance" between a person's current state of knowledge and the potential (yet unknown) level that can be reached by further development and collaboration with more capable peers (teachers, parents, more skilled fellow students, etc.). The concept originated in studies of adult-child interactions; it implies an "asymmetry" of knowledge levels and offers a technique to bridge the gap, whereby a more knowledgeable person assists a learner to reach a higher level, and if necessary changing the learning task so that learners can solve problems or complete tasks that would otherwise be beyond their reach (Vygotsky 1978). However, the theory was not developed in full detail by Vygotsky during his lifetime and thus was not useful as instructional support for computer applications. Vygotskian scholars further developed the concept throughout the twentieth century, with techniques ranging from scaffolding (Wood et al. 1976) to cognitive apprenticeship (Collins et al. 1989). In these refinements and operationalizations, the focus is on support that allows learners to complete their tasks and to gradually become independent problem solvers.

Later studies and system building efforts applied the notion of scaffolding and cognitive apprenticeship to interactive learning environments in a series of trials (e.g., Fischer et al. 1991; Mørch et al. 2005; Furberg 2009). With the aim to identify opportunities for design problem solving and reflection prompting, scaffolding takes on a new dimension, involving a combination of technological tools, tasks, and guidance, supporting students in design activities, argumentation, collaborative inquiry, and making the learning process more transparent. Similarly, through mediation and scaffolding in Second Life, we can create a new dimension of ZPD, drawing on the affordances and constraints of social interaction in virtual worlds: role-play, collaboration between learners and more capable peers, rich (computational) contexts for learning, and contextual back talk (automated feedback).

Vygotsky's theory combines ZPD with play (Vygotsky 1978). Playing is a common denominator in much of Vygotsky's work, as it stimulates motivation and provides a technique for immersion by social interaction. Vygotsky, alongside G.H. Mead, suggested that children use play as a means to grow socially. In play, they encounter others and learn to interact using language, role-play, perspective taking, and various kinds of artifacts. Moreover, this suggests that while learners need their peers or playmates to grow, they need adult feedback for guidance and control, as they master each social skill and move on to learning new skills that depend upon mastery of prior ones.

Role-play theory (Yardley-Matwiejczuk 1997) refines the immersive component of social learning and suggests that role-play describes a range of activities involving participants in "as-if" or simulated actions, where the aim is to construct an approximation of aspects of a real-life situation that is either impractical, expensive, embarrassing, or risky to carry out in the real world. For example, someone may be asked to "imagine" being in a dentist's waiting room, awaiting a painful procedure, or to be a victim of a mugging (Yardley-Matwiejczuk 1997). Role-play may last for short periods of time (minutes to hours) and provide a crude rendering of a complex situation, or it may last for days to weeks, involve many participants, and provide a semi-realistic model of a real-world situation (e.g., simulating a hostile takeover).

Role-play is related to perspective taking, which is a concept in social psychology where one sees a point of view from another person's position and then acts as though one were that person (Mead 1934). Social scientists have studied how people (fail to) take on the perspective of the other when they act on a shared object. For example, during a business transaction of a commodity, both buyer and seller must take each other's perspectives toward the shared object of exchange for proper understanding of the activity. Reciprocal perspective taking is a prerequisite for a group of collaborators to successfully understand a complex situation involving multiple stakeholders with different background and interests, and role-playing can be an effective technique for learning perspective taking (Prasolova-Førland et al. 2013), in particular when the learners take turn in playing different roles (Gillespie 2006).

10.3 Second Life in Teacher Education

Previous work has shown that teacher education programs often have difficulties integrating pedagogical theory and practice (Muir et al. 2013; Reynolds-Keefer 2013). The teachers in training are exposed to several educational methods and techniques that they are required to put into practice in a real classroom. Particularly, many preservice teachers find it challenging to develop professional skills in order to manage classrooms and student behavior (Reynolds-Keefer 2013; Simonsen et al. 2013). Difficulty in terms of implementation could be because theory taught in a teacher-in-training classroom does not connect well with the day-to-day practice in the actual classrooms of working teachers. Many of today's teacher education programs are exploring alternatives to integrate theory and practice. One such alternative is 3D virtual worlds like Second Life. This option provides a platform for practicing various role-playing scenarios that can be useful when teaching theoretical concepts and modeling problematic situations in classrooms. Virtual worlds allow students to engage in social interaction, collaboration, and conflict resolution at a distance (Vasileiou and Paraskeva 2010; Masters and Gregory 2012; Muir et al. 2013; Prasolova-Førland et al. 2013). By practicing working through difficult situations in a virtual environment, teachers in training will get a semi-realistic preview of the equivalent real-life situations.

Although the body of literature concerning SL practice in teacher education is limited (Muir et al. 2013), some researches have suggested that 3D virtual worlds can be integrated throughout a teacher education program in order to provide preservice teachers with the experiences needed to apply teaching skills in real school contexts. Based on these promises, Cheong et al. (2009) used Second Life as an educational platform where 160 preservice teachers were guided to practice teaching skills collaboratively. The findings showed that Second Life seems particularly well suited as an experimental teaching method compared with traditional classroom-based methods.

Vasileiou and Paraskeva (2010) carried out a research project using Second Life to teach role-playing instructions to educators. Role-playing instruction is a strategy broadly used in various educational settings where participants assume different professional roles in a collaborative environment, according to a given scenario. On this basis, they are able to carry out a role-playing game and develop social skills while reflecting on their learning process (Dabbagh 2005; Vasileiou and Paraskeva 2010).

In another example, instructors used Second Life in a distance education course in literature to teach role-playing to 15 primary and secondary school teacher students. The 3D environment showed a positive influence on learner engagement and motivation; and it was found to be especially well suited for socialization and collaboration among the participants, as it "was based on qualities like readiness to collaborate and to communicate, willingness to be exposed and to effectively participate in learning activities, and a genuine and friendly atmosphere" (Vasileiou and Paraskeva 2010, p. 43).

In the VirtualPREX role-play environment, preservice teachers train to develop pedagogical skills and self-confidence before practicing in a real classroom. Gregory and Masters (2012) argue that virtual role-play can enhance the theoretical component of preservice education. Their results showed that although students prefer the real-life version of the learning activity, they find the virtual role-play easier than the face-to-face one, since it provided them with a high degree of immersion. Along the same line of reasoning, Christonasi and Plakitsi suggest that role-play in Second Life is more effective than role-play in face-to-face settings. In virtual worlds, users find it more natural to play a role, feel less self-conscious of their actions, and find it easier to familiarize themselves with social concepts, such as collaboration and knowledge sharing. The learning process through play from the sociocultural perspective can thus be considered a "social achievement" and identifiable in social interaction.

Based on our limited literature survey, we have found that outside of role-playing and perspective taking, key aspects of sociocultural theory (e.g., artifact mediation) are not used in the analysis of teacher training courses conducted in virtual worlds. Our study aims to fill this gap and apply a broader range of sociocultural perspectives in our analysis. We believe it is fruitful for teacher education programs to explore the potential benefits offered by Second Life for practicing teaching skills based on educational theory, especially those skills and concepts that depend upon, or can take advantage of, social interaction, collaboration, and role-play.

Given these findings on teaching and learning in teacher education, our research aims to investigate the following open issues and research questions:

1. How relevant do the preservice teachers find the environment of SL in terms of practicing collaboration skills?
2. How do the artifacts in SL facilitate role-playing activities among learners?
3. How might SL foster social interaction and collaboration through relevant role-playing activities?
4. How can social interaction and collaboration in SL promote learning?

10.4 Methods

A qualitative research analysis was employed, combining a case study (Yin 2003) and internet research (Hine 2000). The use of the case study approach was considered as the proper method for investigating the phenomenon of Second Life as a platform for collaboration and role-playing. A virtual ethnography was employed to collect data on how preservice teachers engaged with the virtual world, specifically how Second Life made collaboration and role-play meaningful.

We examined the use of Second Life in two sections of a graduate-level special education teacher preparation course, held at a North American University. The course was arranged after working hours and used Second Life as the primary educational platform and all course sessions were held online. In total, 34 students were enrolled in the course and took part in seven one-hour class sessions, divided into interactive lectures of theoretical concepts (15 min), individual activities (5 min), small group activities in separate rooms (30 min), and role-play activities in plenum (10 min). During both the group activities and role-play activities, students practiced the collaboration skills that are often necessary for special education teachers (i.e., conflict resolution and interpersonal problem solving). Interviews were conducted afterward. All sessions and interviews were observed at distance and video-recorded (in total 15 h of raw video data) using screen capture software, such as BSR, Camtasia, and SnagIt. Conventional ethical procedures to ensure informed consent were followed, as specified in the Norwegian Social Science Data Services (NSD) guidelines.

In the outset, our research design was informed by a mixed-method approach (Tashakkori and Teddlie 2010), taking into account multiple sources of data: spoken interactions and chat logs, automated screen capture in mp3 or avi formats, questionnaires, and interviews. Questionnaires were sent to the participating students through a web-based survey after the end of the course. However, only seven students returned the questionnaire and only one student and the teacher were available for an interview. Consequently, the outcomes are not generalizable. The questionnaire consisted of nine Likert-type items, with questions centered on the previous experiences of users in Second Life and Second Life's affordances in the learning process. The quantitative data served as a background to help us zoom in on the qualitative data (online interactions and interviews), which is the focus of the study.

In order to collect and manage the qualitative data (spoken utterances, chat logs, and interviews), each session and interview were stored in a separate file and transcribed in its entirety using linguistic conventions according to interaction analysis (Jordan and Henderson 1995). Interaction analysis was chosen because it is concerned with understanding how conversation works, especially verbal communication (textual or oral), as well as how it interacts with nonverbal communication, like intonation, gestures, and nonverbal symbols used in chat (smileys, etc.). However, we excluded nonverbal communication since avatars in Second Life have limited possibility for expressing nonverbal signals of relevance for this study.

To categorize the qualitative data, two researchers reviewed the corpus. We employed an iterative process in which we grouped data by using a so-called open or thematic coding technique (Strauss and Corbin 1998; Givens 2008). Data were placed in named categories as they were "discovered" in the data material (i.e., qualitatively different from previous data), and the categories were adjusted as we identified new instances of data. This form of data encoding is linked to grounded theory (Strauss and Corbin 1998), because it starts with a "clean slate" (with a minimal assumption of what to find, systematizing data along the way or bottom up). However, it is difficult to start with a clean slate because any analysis is based on researchers' prior knowledge, experience, and prejudices, and the premises and constraints defined by research projects (e.g., project aims, learning goals, research questions, theoretical perspectives) (Givens 2008). We have therefore used a combination of bottom-up and top-down systemization of the data included in our information. The following three categories have been identified as most representative: mediating artifacts, role-play, and social interaction.

10.5 Data and Analysis

We organized the data thematically into three thematic categories: mediating artifacts, role-play, and social interaction. We reproduced eight excerpts of interaction data and interview data as representative examples of the three categories, which we use to substantiate our claims.

10.5.1 Mediating Artifacts

The majority of the preservice teacher participants were first-time users of Second Life (SL). Data transcripts and questionnaire responses showed that the learning activities in the virtual world environment provided them with an increased awareness of how to apply the theoretical concepts taught in the course. The PowerPoint slides occupy a significant position within the main classroom, allowing students the visual representation of the theoretical concepts in a shared and dynamic space (Fig. 10.1).

Fig. 10.1 Teacher and students discuss the theoretical concepts shown on the poster slides along the walls. Two researchers are observing the event

10.5.1.1 Excerpt 1: PowerPoint Slides Mounted on Poster Stands

In the following excerpt, the teacher shows and discusses with the students a series of concepts taken from the subject matter being taught (special needs education) by means of PowerPoint slides mounted in the virtual classroom walls (Fig. 10.1).

Teacher:	*Let me just look at these other slides real quick to see if there was anything else with the resolving conflict I wanted to (. . .) to talk about before (. . .). Time goes so fast in here (. . .) ahm:: You can read these slides, I'll put them in a box for you (. . .) ahm, at the front of the . . . Yes, the rest of these are pretty self-explanatory so: ahm, we'll move on to . . . There are two slides I want to talk about with conflict before we move onto resistance (. . .) So if you could follow me to the other side of the room (. . .) these are my two favorite quotes ever (. . .) So this first quote here, and you've seen it in your group buildings (. . .) it's by Isaac Newton and it's, 'Tact is the art of making a point without making an enemy.' (. . .) So the next time that you're involved in a conflict situation (. . .) I want you to think of that quote: 'Tact is the art of making a point without making an enemy' (. . .) How could approaching conflict from this perspective change the way that you're involved in it?*
[14:42] TL:	*my reaction*
Teacher:	*How could that change your reaction, TL?*
[14:42] HM:	*You will approach the conflict with an open mind rather than feeling you need to defend yourself.*
[14:42] TL:	*Be more understanding of the other person.*
[14:42] MG:	*Only Newton could have said something like that.*
[14:42] MS:	*To be more sensitive*
[14:42] AD:	*Approach it calmly and make your points well thought out.*
[14:42] ST:	*Try to see the other person's point of view.*
[14:42] YD:	*Think before you speak.*
[14:43] LJ:	*Calmly*
Teacher:	*you approach the conflict with an open mind rather than feeling you need to defend yourself (. . .) excellent (. . .) Be more understanding of the other person (. . .) definitely (. . .) MG, yes ((laugh)) only Newton could have said something like that (. . .) definitely (. . .) MS, to be more sensitive. AD, approach it calmly and make your points well thought-out, definitely (. . .) ST (. . .) try to see the other person's point of view (. . .) excellent (. . .) YD, think before you speak (. . .) Ahm:: and:: (. . .) LJ says calmly and with that in mind (. . .) if you think about this before you get involved or when . . . in the moment that you're involved in a conflict situation.*

The preservice teachers learned about theoretical concepts, such as conflict and resistance, by observing the questions presented in the slides, discussing, and sharing their opinions with the rest of the class. The teacher at the end of the first utterance asks the students a question, which they answer one by one (most of them using chat). The teacher repeats their answers and gives them constructive comments (using voice).

Fig. 10.2 Preservice teachers are actively involved in running the role-play activity. They have a "*box*" positioned on the table to share and access documents

10.5.1.2 Excerpt 2: The "Box" as Mediating Artifact in Second Life

All the interviews took place after the end of the course. The following is an excerpt from the interview with the teacher.

> *When I first started teaching, in Second Life, before I went to the Sloan training (. . .) I used to type everything into the chat text. ((Well)) then it would disappear, and so I'd have to type it again. Or, I - I IM'd every student individually (. . .) um, like by typing, for the instructions. Um, and it was very ineffective and very non-time efficient, because it would take me forever to type to each student what they were suppos:: and (. . .) so, the boxes, once I learned how to build the boxes, in order to disseminate the information, that was the way that – was the most efficient. Um, so far (. . .) for getting that information to multiple people.*

The teacher explains why she prefers to use "boxes" for sharing information (Fig. 10.2). The choice of using boxes was considered an easy way to communicate information.

These tools (boxes) are then used both by teacher and students as a special type of SL artifact, as an efficient way to create and share documents and other files among the group (Fig. 10.2). However, just like an overhead projector is a tool for teachers, their usefulness is not always apparent and sometimes tools break down. We also found this to be the case here. Some groups encountered difficulties in making the boxes available for the rest of class to buy (which is the technique in SL required for getting content out of boxes). In other words, we observed a discrepancy in perceived benefit in using the artifact among the teachers and some of the students, or alternatively there is a relative steep learning curve for understanding how to use this tool.

10.5.1.3 Excerpt 3: From Notecards to Boxes: Artifact-Mediated Collaboration

In the following excerpt, preservice teachers are working in small groups. After creating a scenario for the role-play activities, they need to create notecards, intended as instructions for the actors, which are then put in the boxes (see Fig. 10.2).

JK:	*Could we make the scenario between the collaborating . . . the two collaborating teachers, Miss Williams, the special ed teacher and I forget who the English teacher was, ahm:: but between them two and how they think that they should help him?*
[14:16] MS:	*Mr. frost*
HM:	*What if we were to make it with the principal? What if it would just be an IEP meeting?*
[14:16] JK:	*Good idea.*
HM:	*We just want it to sound like and look like the ahm:: students are . . . (. . .) well, our peers will be in an IEP meeting discussing Franklin (. . .) and:: we're going to . . . is it going to be the negotiation skills they're going to practice?*
[14:17] JK:	*Yes.*
[14:17] MS:	*Yes.*
ST:	*OK, now that we have kind of the scenario and the skills, everybody in agreement with what we have for the scenario and the skill?*
[14:17] MS:	*Yes.*
[14:17] JK:	*I am.*
[14:17] HM:	*Ok.*
ST:	*OK, now we need somebody to make the box.*
HM:	*You all go together and do that. I kind of . . . can we build it in here?*
ST:	*I'm not sure if we can or not.*
HM:	*I think we can build it here, we just have to put it in our inventory before we leave. I have one (. . .) started, I'll try to get it so you can see it.*
[14:18] JK:	*Exactly.*
[14:18] ST:	*Ok.*
HM:	*That's a fancy box. Is it changing:: the scenery on it or are you changing that? (..)*
MS:	*Yeah, can you see it?*
HM:	*Yeah, I can ((laughs)) (..) OK, tell me when you . . . we get something that you like.*

In this instance, the learning process in the 3D virtual world had a positive impact in relation to the understanding of the subject matter, since learners performed their tasks together and simultaneously. By creating and working on the same artifacts at the same time, the learning experiences became more collaborative and artifact-oriented than just communicating with peers.

10.5.2 Role-Play

The preservice teachers in training were asked to create a role-play scenario based on a case study assignment (the "Franklin case:" Franklin is the fictive name of a young boy diagnosed with a social anxiety disorder). They were assigned to select collaborative skills for their classmates to practice during the role-play activity. In addition, each member was assigned a specific role in coordinating the activities: leader, organizer, timekeeper, secretary, and facilitator.

10.5.2.1 Excerpt 4: Planning Role-Play Activity

The following excerpt shows how one of the preservice teacher groups planned their role-play activity:

ST:	*Is our situation going to be like Franklin and other – and other teachers or is it going to be like teachers talking about Franklin or:: (...) what? You know, what kind of scenario? I think we've got to think of what kind of scenario first and then think of what kind of skill we should practice.*
[14:14] JK:	*True.*
JK:	*I think that we could do something like ahm:: the teachers talking about what they can do to help him, like what is the best help. I mean, because that's kind of what we've struggled on too, what is the best help for Franklin? Do we try and seek counseling for him, do we just punish him for making dirty pictures and making shanks at home, like what is the best for Franklin?*
[14:14] ST:	*Ok, that sounds good.*
ST:	*So do you think that might fall under negotiation? (...) Because they're ... teachers are kind of negotiating with each other about (...) what would be best for him.*
[14:15] JK:	*I think that or conflict*

By planning the role-play activities in collaboration, students were highly motivated to take part in the group discussions, thus making sense of the theoretical concepts taught in the course, such as negotiation, resistance and conflict.

Particularly, the excerpt illustrates how the role-play in Second Life provided the preservice teachers with a significant level of immersion and realisms, since they interpreted their roles by practicing real collaboration skills and exploring learning situations more safely than in the real world, which is further illustrated in the next excerpt.

10.5.2.2 Excerpt 5: Comparing Real and Imaginary Situations

The following excerpt is taken from the interview with one of the students who was asked what advantages and disadvantages one can identify in virtual role-play compared with the real-world counterpart:

> Being on Second Life was (...) uh (...) oh what's the word I wanna say, it was not as intimidating as if I would have had to stand up and role-play with someone in person so I just I felt more confident.

By role-playing the scenarios several times without any of the moral responsibility, they would have had in a real classroom, preservice teachers got the opportunity to both act and reflect on the learning process. By being engaged in reflection and discussion about the role-play, learners were able to explore different classroom management strategies before acting them out in real life.

10.5.3 Social Interaction

The findings showed that the Second Life environment fostered a form of social interaction that is supportive of collaboration by catering to meaningful communication without expressing prejudices among its users.

10.5.3.1 Excerpt 6: Comparing Face-to-Face and Virtual (SL) Communication

This excerpt is taken from the student's interview. She was asked what differences exist between communication in SL and communication in the real world.

> I think it's easier to speak in SL because you don't see the other person looking at you and . . . a little more outgoing . . . If I was in that room with other people it would have taken me a little bit longer to get adjusted and acclimated to everyone's personalities. And I think it's harder in real life because you can't just go to the chat walks and make a quick statement. You have to sit there and wait for people to stop talking. There are certain social norms you have to follow. But with SL you can go to the chat walks and make statements and there were still some times we tried to be polite with each other and to follow the social norms.

We can glean from the transcripts that the virtual learning environment in Second Life offered many opportunities for rich social interactions, since the students felt more confident about taking part in learning activities due to the lack of prejudices based on the users' face-to-face appearance. However, having an active role in SL learning activities also required oral skills combined with textual discourse (chat). Preservice teachers used both means of discourse. However, they seemed to prefer using chat in order to avoid sound problems with the "speak" button and the noise associated with multiple people attempting to speak at the same time.

10.5.3.2 Excerpt 7: Role-Play Successfully Planned by Collaboration

In the following excerpt, one of the groups has just finished planning the role-play scenario:

JK:	*We've got everything (. . .) in a line now, which makes me feel a whole lot better.*
HM:	*I had no doubt that we could do it, we're superwomen.*
[16:04] ST:	*Go team! Ha ha.*
MS:	*We were just overachieving with trying to write a behaviour plan.*
HM:	*I know, I think we were just . . . I tend to do that a lot, over-think things. But I'm glad that you guys met with her and you realized it's not as much as we were making it out to be.*

[16:05] JK:	*Ha ha, we are super*
MS:	*I'm glad that we thought it was harder than it really was instead of (. . .) expecting it to be really easy and it turning out to be really difficult.*
[16:05] HM:	*Yeah.*
[16:05] JK:	*Exactly.*

Although some students encountered technical difficulties managing their own avatars, we found that the support of the virtual environment was in general very good; it enabled collaboration and increased motivation and engagement. It is worth noting that even though some students had difficulties in the beginning and feared it would not work out, it turned out to be the opposite for most of them, as the following quote from the excerpt illustrates: "*I'm glad that we thought it was harder than it really was.*"

10.5.3.3 Excerpt 8: The Feeling of Belonging to a Group

The following excerpt, taken from the interview with the teacher, shows why SL was found to be the more suitable educational platform in many respects, and particularly in fostering social interactions among learners:

> Um, social interaction in Second Life, I feel like, is – Second Life lends itself to social interaction, as compared to Wimba [an VLE integrated with Blackboard LMS]. So, for distance education, I think, Secon:: – for me Second Life is the (. . .) my preferred educational platform for social interaction, because you actually get the physical presence of a person. And, in, um, Wimba, unless you're using video conferencing (. . .) you don't get that physical presence of a person (. . .) Um ((and that this class)), being in Second Life, it – it really helped them to feel like they were part of a group again. Um, were they didn't have – they felt disconnected. From the, um (. . .) inst:: from online education. With being in Wimba. They didn't feel connected to other people.

Compared to other platforms supporting online learning based on synchronous interaction and artifact mediation, the virtual environment of Second Life seemed particularly well suited for distance education, as it features a 3D-graphical representation by means of avatars that are able to interact and communicate with audio or chat.

10.6 Summary of Findings

The results of the data analysis indicate that the learning we observed in Second Life was highly motivating for the students. They took part in collaborative and role-play activities and were deeply engaged; they applied the theoretical concepts taught by the teacher, which in turn aided the students' learning of key concepts in special needs education. The latter is a hypothesis at this stage, which we intend to study in more detail in subsequent work.

We also observed that well-designed virtual learning activities and a teacher's constructive feedback and in situ guidance by visiting each of the working groups in a round-robin fashion facilitated the group work. For example, Excerpt 1 shows that the group members expressed their opinions through more complex and analytic discourse. They were able to contextualize the conflict situations described in the scenarios by role-play (Excerpts 3–4). This also allowed them to practice collaboration skills, involving critical thinking and cooperative problem solving (Excerpts 5–8).

Second Life cannot replace real classroom practice, but the results we report suggest that SL had a big impact as a new kind of mediating artifact, defining new ways for teachers and learners to communicate in a semi-realistic manner (Excerpt 2). This artifact was indeed effective because we observed that the students did not have time for socializing, which was also confirmed by the teacher during the interview. The students were immersed in developing their own understanding of the concepts taught in the course by making scenarios modeled after real classroom situations and playing them out.

10.7 General Discussion

We discuss our findings according to the four research questions raised in the beginning of the chapter, and compare with the findings reported in the literature.

10.7.1 How Relevant Do the Preservice Teachers Find the Environment of SL in Terms of Practicing Collaboration Skills?

The findings from the study indicated that the interactive nature of Second Life fostered social interactions and collaboration by means of role-playing activities. The sense of physical presence created through avatars and the immersion created by the 3D environment allowed learners to be engaged more effectively in practicing collaboration skills. The Franklin case in Excerpts 3 and 4 is an example of this. The outcomes of this study showed that Second Life not only was particularly well suited as an experimental teaching method compared with the traditional classroom-based methods (Cheong et al. 2009) but also that the virtual role-play turned out to be an excellent way of applying the theoretical concepts taught in the course. Indeed, role-play in Second Life seemed very effective; the participants enacted their roles less self-consciously than in the real world, as judged by our observation that the participants were not influenced by the embarrassment that may occur in a real context.

10.7.2 How Do the Artifacts in SL Facilitate Role-Playing Activities Among Learners?

Several artifacts were built by the teacher and made available to all participants, such as presentation slides, wall posters, boxes, notecards, etc., allowing easy access to required information and providing participants with ubiquitous access to the theoretical concepts covered in the class. This was possible because Second Life provides its users with many significant and mediating artifacts influencing human activities (Tondeur et al. 2013; Prasolova-Førland et al. 2013). The preservice teachers had an active role in the learning process, as the tasks were open ended and required improvisation, knowledge sharing, and some teacher guidance and prompting. By enacting the scenarios and practicing social skills in role-play with their self-created avatars, students showed a high level of engagement. The case study demonstrated that Second Life is a platform with a set of flexible tools for communication, coordination, and collaboration that will encourage users to create a strong sense of group cohesion. However, the majority of the preservice teachers were first-time users of Second Life and mastering the technology required some time, especially for adjusting audio input/output.

10.7.3 How Might SL Foster Social Interaction and Collaboration Through Relevant Role-Playing Activities?

Observations and data transcripts showed that the collaboration within the groups was successful since the members were able to share information by means of different communication tools (voice and chat). Furthermore, they could work with predesigned, semi-structured learning activities in order to practice both social and technical skills and gain new ones (e.g., interpersonal problem-solving and technology skills). Second Life enabled social interaction by supporting meaningful communication in different types of situations, allowing the users not only to develop social skills and reflect on their learning process (Dabbagh 2005; Vasileiou and Paraskeva 2010) but also to develop agency: to take an active part in the learning process with a confident attitude.

Compared to other online learning environments, such as the asynchronous environments Moodle or Wimba, the synchronous 3D virtual world seemed more suitable for distance education in this kind of learning community, (i.e., 20–35 students), as the avatars' graphical representation gave the participants a sense of "physical presence" in the online learning environment, which again made it easier for them to feel that they are part of the study groups. Despite these benefits, some of the students encountered technical difficulties in managing their avatars and gaining access to the required objects. Nevertheless, we found that the structure imposed by the virtual environment was relevant and sufficient; it let the learners be actively engaged within a few (1–2) hours of use.

10.7.4 How Can Social Interaction and Collaboration in SL Promote Learning?

When analyzing the data in terms of students' individual achievements, we observed that Second Life provided the participants with individual ZPDs based on a combination of interaction, contexts (university, work, home), more capable peers (teachers and advanced students), and tools mediating actions in SL. This trialogical connection allowed for a lever of confidence within the students' ZPD, providing a (motivational) bridge for linking social learning and cognitive development (see Excerpt 5). This should be considered a hypothesis at this stage, requiring more detailed research to elaborate.

10.8 Conclusions and Directions for Further Work

The finding from this study indicates that learning processes based on collaboration and role-play can benefit the support of a 3D virtual world like Second Life. This type of synchronous online learning environment provides a semi-naturalistic setting for practicing collaborative skills mediated by a new class of artifacts, which are highly adaptive and modifiable by skilled teachers.

However, some limitations should be cautioned; the learning activities depended on the active participation of teachers and students. The success of role-play as a learning method depends on the teacher's planning of the learning activities according to educational goals. In one of the interviews, a student said: *"There are other classes I think Second Life wouldn't work very well, but with a specific style of course where we were learning how to collaborate with people, I thought Second Life was . . . mhmm . . . absolutely a wonderful tool!"*

Despite the potential of 3D virtual worlds in education, research interest in this field is still in an embryonic stage. Thus, 3D virtual worlds need to be integrated throughout teacher education programs in order to provide preservice teachers with necessary experiences to apply professional skills in real school settings. In this area, there is plenty of opportunity for more research.

The findings of this study were in part limited by the lack of sufficient interviews with the students and questionnaire responses. This can be attributed to the fact that students were asked to volunteer to fill out a questionnaire and take part in an interview after the end of the course, coinciding with end of semester holidays and after a busy workday (the participants were preservice teachers).

An important direction for further research is to compare and discuss the pros and cons of virtual teaching and traditional teaching of topics in education. Moreover, for space reasons, it was not possible to analyze how the use of the 3D environment impacts social presence. In further work, more attention should be paid to combining traditional pedagogical approaches and virtual world pedagogy, especially in situations requiring or lending itself to collaborative learning, team work, social interaction, and learners' involvement in open-ended (e.g., design problem solving) educational activities.

Acknowledgments The first author (Caruso) is grateful for a stipend received by the University of Palermo to visit InterMedia, University of Oslo for a 6 months research stay. The second author (Mørch) is partly funded by Småforsk (seed money) from the Department of Education, University of Oslo, to explore Second Life as a platform for distance education courses.

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Chapter 11
On the Usage of Health Records for the Teaching of Decision-Making to Students of Medicine

Marcus D. Bloice, Klaus-Martin Simonic, and Andreas Holzinger

Abstract The development of clinical reasoning and decision-making skills in medicine is inextricably linked to experience. Yet students are failing to gain this experience before embarking on their first medical jobs. This is due to several factors, including advances in medical science resulting in patients that are less likely to be hospitalized and more likely to be treated in outpatient departments. This lack of experience within real-world scenarios has resulted in students feeling they are ill prepared for their first medical jobs. One way to counter such a lack of experience is through the use of software simulations such as Virtual Patients. However, simulations are extremely costly to develop, in terms of both financial outlay and the time required to create them. We report here on the development of an iPad-based Virtual Patient simulation system that uses annotated electronic patient data and health records for the creation of cases to enable students to learn critical decision-making skills. By basing these Virtual Patients on abundant patient records, cases can be more quickly and easily created, thus enabling pools of cases to be accumulated—essential for gaining the experience required for the development of sound clinical reasoning skills.

Keywords Decision-making • Virtual Patients • Clinical diagnostic reasoning

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R. Huang et al. (eds.), *The New Development of Technology Enhanced Learning: Concept, Research and Best Practices*, Lecture Notes in Educational Technology, DOI 10.1007/978-3-642-38291-8_11,

11.1 Introduction

This chapter describes the development of a Virtual Patient application known as Casebook, which runs on the Apple iPad family of tablet devices. The Casebook application, or app in iOS parlance, teaches students of medicine decision-making through the use of Virtual Patient cases that consist of anonymized and annotated electronic health records. Electronic health records can consist of lab reports, X-rays, electrocardiograms (ECGs), or any other electronically available patient data. This is similar to how Case-Based Learning is performed—where students are guided through a patient case in specially organized seminars and the patient is discussed as they go along. Casebook reads case files which are specially formatted archives of health records that are organized into a timeline of events and examinations that describe a patient's treatment. Students navigate through these cases and, at certain points throughout the case, must answer questions relating to the patient. These questions normally take the form of "what would you do next?" propositions. When the student has answered a question, the next patient record is revealed thus showing the actual course of events that took place when the patient was treated by the physicians.

This chapter will first describe some of the theories of how to properly undertake the task of teaching clinical reasoning and decision-making. We will introduce what aspects of these teaching methodologies are addressed by the Casebook application and provide arguments as to why the application was designed in this way. Here we discuss why, by using real patient data organized into cases, we can address many of the current teaching methodologies described in recent literature.

Following this, we introduce the Casebook application itself, show how it is used, describe typical usage scenarios, and walk through a typical case presentation. A video of the application in use has also been provided on YouTube to allow readers to experience the look and feel of the application in actual use.

Finally, this chapter will also describe in detail how cases are created, archived, and stored and reports on technical aspects of the development of the application (our group has previously reported on some preliminary prototypes (Bloice et al. 2011a, b)). The ability to easily create, interchange, and archive cases is of paramount importance for the success of the application in terms of the design goals that were stipulated at the beginning of the project.

This chapter concludes with an outlook regarding the future direction of the application's development.

11.2 Teaching Clinical Reasoning

There is much material regarding the proper teaching of clinical reasoning to students of medicine. A thorough investigation into the multitude of methodologies and strategies used to teach clinical reasoning and decision-making is beyond the scope of this chapter—however, this section will describe some of the more notable theories that shaped and influenced the design of the Casebook application. By first examining the literature regarding clinical reasoning, and then deciding which aspects of these methodologies could be transferred to a software environment, our group was able to decide how to develop and engineer the Casebook application. This top-down approach meant that our initial requirements were theoretically sound as they were based on well-established and proven arguments from peer-reviewed literature. In other words, this section aims to legitimize and provide the rationale for our design decisions by describing here the literature that guided the application's development.

Judith L. Bowen's review article in the New England Journal of Medicine provides an excellent introduction to the strategies that can be employed to promote clinical reasoning in medical education (Bowen 2006). One major theme throughout Bowen's article is the idea that students should be encouraged to develop "illness scripts" which enable for proper diagnostic reasoning. Illness scripts, according to Bowen, can only be developed when previous experience with similar patients enables the student to recognize certain symptoms that point to certain diseases. Without this experience, students find it difficult to translate their theoretical knowledge learned in the classroom to real-world scenarios that students will encounter when they become doctors. Also, experience is invaluable to the clinician as it is the recollection of these experiences that allows them to recognize the subtle differences between similar cases and patient presentations. This argument is reiterated by Normal et al., who state that it is the "power of the plural" which is key to learning diagnostic reasoning and decision-making (Norman et al. 2007).

Traditionally, students have been able to gain experience, and therefore hone their clinical reasoning skills, by dealing with patients while performing ward work during their medical education or clerkships. However, as pointed out by Whitcomb (2006), the changing face of healthcare has resulted in students experiencing less time on wards and gaining less experience with patients with common clinical conditions. This is for several reasons: advances in medical science have resulted in patients being treated in outpatient departments rather than needing to be hospitalized, symptom evaluation is increasingly being performed externally from hospitals (Huang et al. 2007), and students are spending less time on wards due to time and monetary constraints (Young et al. 2009). Simply put, students are seeing less patients as examples of clinical cases (Sanson-Fisher et al. 2005).

Because students are spending less time on wards and are more likely to encounter patients that are exhibiting less common symptoms during their training, it should come as no surprise then that students feel apprehensive about the transition from student to doctor—studies performed by Goldacre et al. (2003) and Cave et al. (2007) have shown that students feel ill prepared for their first medical jobs. According to Goldacre et al. (2003), over 41 % of students either disagreed or strongly disagreed with the statement "My experience at medical school prepared me well for the jobs I have undertaken so far." Respondents to their surveys described that a lack of training that deals with basic problems found on wards and a lack of emphasis on real-life problems were the root of these feelings of unpreparedness. Similar results were found in Germany, where close to 66 % of doctors felt poorly prepared for work after graduation (Ochsmann et al. 2011).

These aspects are very important in terms of the decision to design Casebook to use real patient records as the basis for creating Virtual Patients. We believe that by basing Virtual Patients on electronic health records, we can tackle these issues from two directions: First, our group believes that by creating pools of similar cases (i.e., cases where each patient exhibits very similar symptoms) students can learn to develop, at least partially, their clinical reasoning skills using this multitude of cases—thus better preparing them for real ward work upon graduation. Second, students feel they are unprepared for their first medical jobs because they have not had enough contact with patients with common conditions. To mitigate this, our group is of the opinion that it must be as easy as possible to generate Virtual Patient cases. If cases can be easily generated or created, then we believe tutors would be more willing to create Virtual Patients that revolve around more common, unexceptional, or simple problems.

Section 11.3 explains in more detail the reasoning behind using patient records to create Virtual Patients.

11.3 Using Electronic Patient Records for Teaching

From the previous section we have seen that learning clinical reasoning can be facilitated through the repeated examination and study of similar patient presentations, in order for students to develop strong illness scripts and to hone diagnostic decision-making. However, what we have also seen is that (a) students feel ill prepared for their first medical jobs and (b) advances in medicine have meant students experience less time on wards and come into contact with fewer patients than ever before. Often, Virtual Patient simulation systems are touted as being good replacements for such situations where it has become more and more difficult for students to experience real-life work and thus improve their perceptions of preparedness and learn proper diagnostic reasoning (Cook and Triola 2009). Indeed, simulations are regarded as "fertile ground" for compensating for exactly this lack of proper experience (Bordage 1999). More recent literature describes ward simulations as particularly suitable in this era of patient safety (Mollo et al. 2012). In fact, much research has shown that simulations do indeed increase retention rates in medical education (Holzinger et al. 2009).

So, although simulations can help to mitigate some of the effects of decreased real-life ward work in medical education, we would argue that most simulations do not in fact do this. A review article published in 2007 by Huang et al. (2007) reported on the usage and costs of Virtual Patients in US and Canadian medical schools. They found that 85 % of individual Virtual Patients cost over $10,000 to produce, while 35 % of Virtual Patients cost over $50,000 to produce. They also found that the average time required to produce one Virtual Patient was 16.6 months. It is therefore quite inconceivable that Virtual Patients which are produced or manufactured in such a way could be built in the numbers required to properly teach students clinical diagnostic reasoning. Again, the proper teaching of diagnostic reasoning and decision-making skills requires that multiple patient cases be available, where each case's patient presentation differs only subtly. Also, as mentioned in the previous section, students complain of not having seen enough patients with common conditions and prototypical patient presentations. Cases which cost $10,000 are unlikely to be based on common situations or conditions. Nor will the pools of cases that are required to teach clinical reasoning be accumulated when it currently takes over 16 months to create a single Virtual Patient. This has resulted in cases being based on atypical patient presentations, uncommon pathologies, or unexpected reactions to treatment—for the very reason that creating cases for common clinical situations does not warrant the monetary or time investment required. Such cases do not help students who have apprehensions about treating patients with more common conditions and diseases.

Indeed, returning to the work of Bowen (2006), students should be shown patients with prototypical presentations, and then as the student learns to be comfortable with the features of this prototype, they should be introduced to patients with subtle or atypical diagnoses resulting from a similar presentation. Such depth, we believe, cannot be achieved with produced or manufactured Virtual Patients, as they are simply too expensive to create. Therefore, we would argue that creating Virtual Patients—in greater numbers—from electronic health records is a more viable method. Hospital information systems contain a large amount of easily accessible patient records, which, when anonymized, annotated, and organized correctly, could be used to create multitudes of Virtual Patients.

There are other advantages to using real patient data for the creation of Virtual Patients. For example, cases based on real patient data could be used to teach good documentation practices, by presenting students with cases where good practices have been followed. Examples of bad documentation could also be highlighted in a similar way. Likewise, students can be presented with cases where misdiagnosis occurred, to teach them how to avoid diagnosis pitfalls, and so on. Also, colloquialisms and abbreviations that are region or country specific can be taught by showing cases from the university hospital in which they will eventually work. Physicians spend a great deal of time documenting their work. In fact, a survey conducted by Oxentenko et al. (2010) found that nearly 68 % of doctors spend over 4 h per day writing documentation, while only 38.9 % spend this time in direct contact with their own patients. It would make sense, therefore, to maximize the use of patient records and documentation when so much time is invested into this task.

The aim of Casebook, therefore, is to be a platform upon which such Virtual Patient cases can be viewed. Once a patient case has been created by a physician or tutor, the case can be loaded and navigated using the Casebook application. The following sections describe the Casebook application that has been developed and outline in detail how cases can be created from electronic patient records and then viewed using an iPad. Through the use of annotations, physicians can describe their logic and reasoning as well as their thought processes behind making certain decisions. They can highlight values in a lab report which stood out or point to a symptom or group of symptoms which led to an original working hypothesis. Such annotations are essential insights into the working minds of physicians whose actions students must one day emulate and perform themselves.

11.4 The Casebook Application

The Casebook application itself, which runs on the Apple iPad family of devices, allows for cases, which consist of patient records organized temporally, to be viewed by students who must also answer questions as they progress. In order to facilitate the description of how the application functions, a video demonstration of Casebook in use has been created which highlights some of its features, such as navigating through part of a case and answering questions. The video is available on YouTube under the following URL: https://www.youtube.com/watch?v=x5R6RZsRTq0. However, the application's main functionality will also be described in this section, along with a technical description of how cases are imported and displayed, how cases can be stored or archived, and how cases are created.

11.4.1 Using Casebook

Students are intended to use the application in seminar scenarios, either in small groups or individually. Tablet devices, which are omnidirectional and can be passed around easily within groups, make for ideal learning devices for small numbers of students working on a task together. Whether students work alone or in groups does not alter how Casebook is actually used, however. Upon starting Casebook, the student is immediately presented with a welcome screen that displays instructions on how to use Casebook and highlights its main features, as well as describing what each of the buttons on the toolbars do. Because most students will not have seen or used the application before, it was important to offer help from the moment the app starts. These instructions can be scrolled through from left to right and describe the basics of Casebook's functionality. The instructions view is one of four tabs that constitute the application's main front end. Figure 11.1 shows the third tab in the toolbar, which contains the cases that are currently stored on the device.

Upon choosing a case, the student is presented with a number of sections, as seen in Fig. 11.2a. When a case is first opened, only the first section is available to view. Only after finishing the first section may the student begin the second section and so on. When all sections are complete, and the case has finished, the student is presented with the view seen in Fig. 11.2b. Sections could represent hospital departments, visits, stays, and so on.

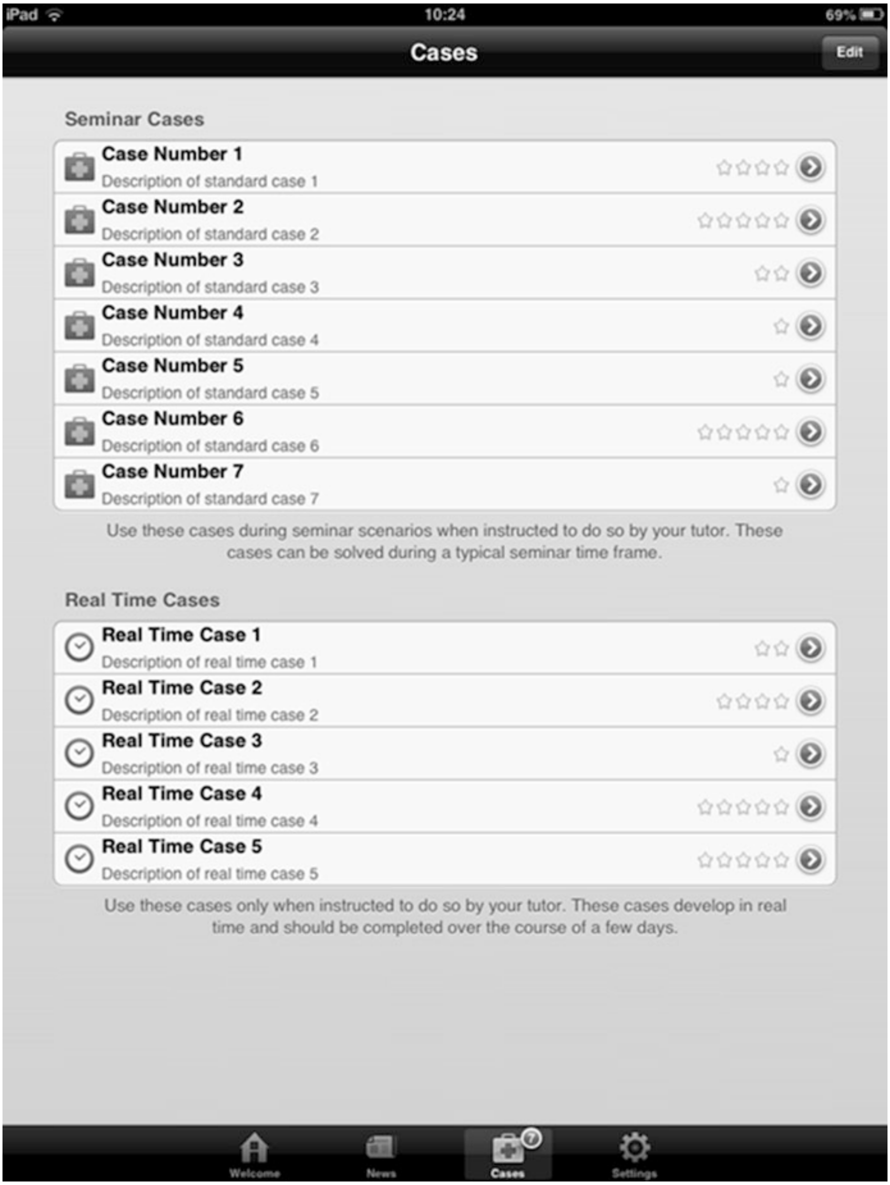

Fig. 11.1 Displaying the cases that have been imported into the Casebook application. Cases are displayed with a rating, given by the student at the end of completing a case. Students should be instructed to rate the case according to how well the case was constructed

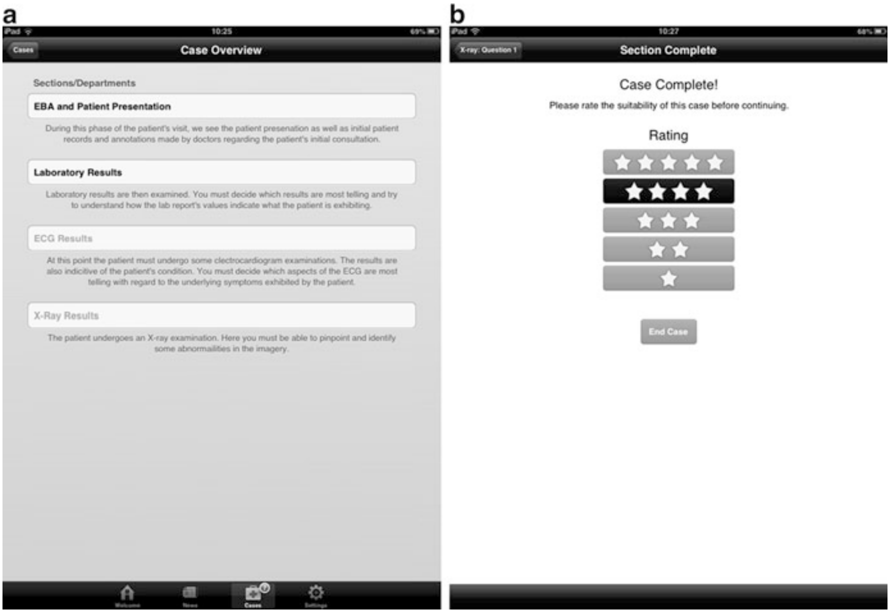

Fig. 11.2 Cases are organized into sections or departments (**a**). Once a student has viewed and answered the questions of a department, the subsequent group of patient records appears for selection. This follows on in a linear fashion throughout the case until all departments have been completed, at which point the case ends and the student must rate the case before continuing (**b**)

Once a section has started, a student is generally presented with a patient presentation document or other such health record, as seen in Fig. 11.3a—the order in which patient records appear is stipulated by the case's descriptor file, described in detail in Sect. 11.4.2. When viewing a patient record, annotations may be available for the student to view. If annotations are available, a small icon on the bottom right of the toolbar is enabled. By tapping on the annotations button, a new screen curls into view showing the annotations for that particular patient record. Figure 11.3b shows such an annotation view for a patient record. The annotation view can be dismissed by tapping on the curled up page on the top of the screen, which returns the user to the original patient record.

Once the student has read the patient record and any annotations that may be available, they should proceed to the next document by tapping on the *Next* button in the navigation toolbar. At various points throughout the case, questions should be answered by the student. Figure 11.4a shows an example multiple-choice question that must be answered by the student before they can continue. Questions can contain hints that can be accessed by tapping on the appropriate icon in the toolbar, as shown in Fig. 11.4b. If no hints are available, the icon is simply disabled. Once the students have selected their answers, they must submit them to check if they

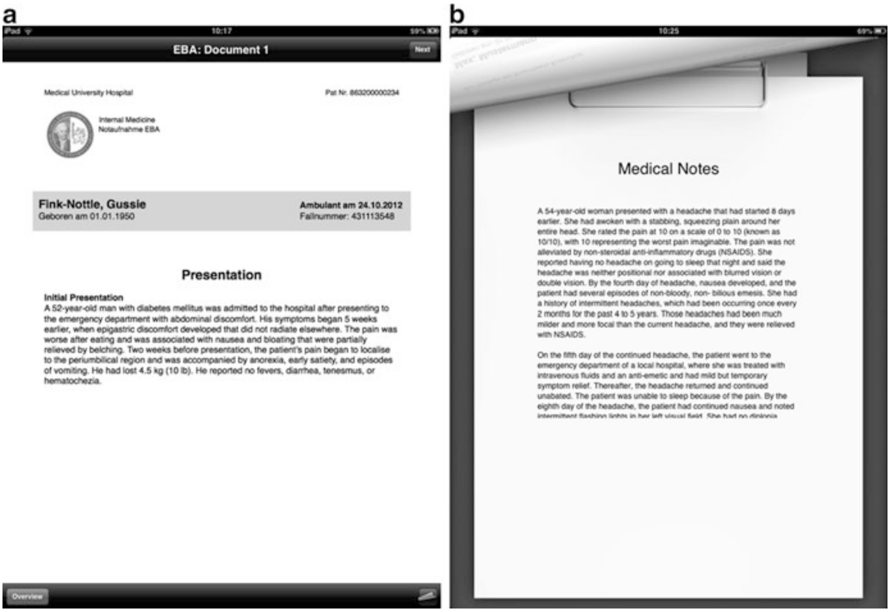

Fig. 11.3 The student views the first patient record in (**a**). The patient record view contains two toolbars: the toolbar on the top of the view is used to navigate left and right through the patient case. The toolbar on the bottom contains buttons for returning to the list of departments or for accessing annotations. It can be seen in (**a**) that the annotations icon is enabled on the toolbar, meaning annotations are available to view. Tapping this icon results in the annotations shown in (**b**). These annotations serve to give students insight into the decision-making and thought processes of the physician

were correct. Students are given immediate feedback, and only after submitting their answers can the student navigate to the next patient record.

This procedure continues until the section is complete. Once a section is complete, the user is returned to the list of sections seen in Fig. 11.2a, where the next department can now be selected. This continues until the student has completed all sections of the case.

Cases themselves are imported into the application by the tutor or professor. The subsequent sections describe how cases are created, stored, and imported into the Casebook application.

11.4.2 Case Format

Cases for use in the Casebook application consist of two main entities:

- A collection of patient records (in PNG format)
- A single descriptor file (meta.json)

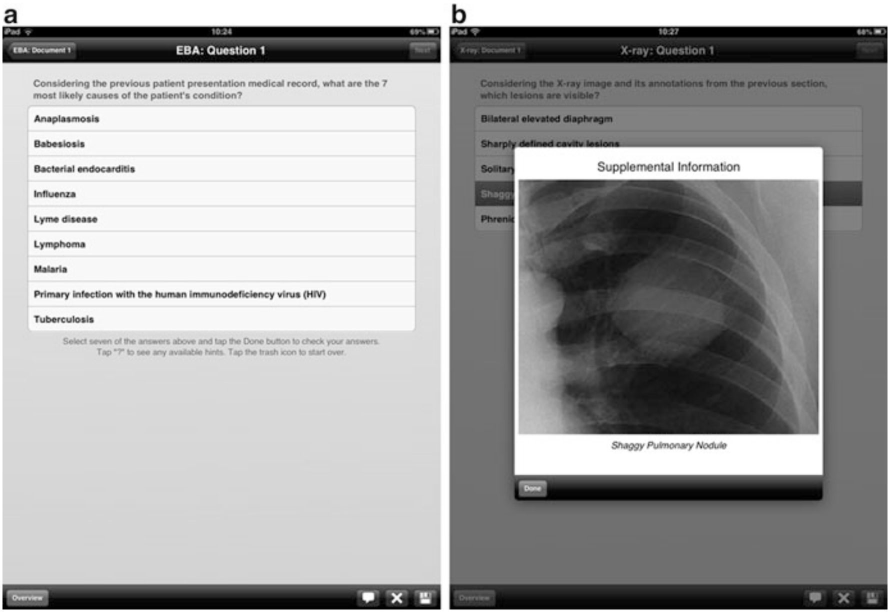

Fig. 11.4 In (**a**) the student is presented with a multiple-choice question which must be answered before the next patient record can be seen. In (**b**) hints are shown. If hints are available, the hints button on the toolbar is enabled. Hints may contain images or textual information to help the student when answering questions. Multiple-choice questions can be single or multiple selection

The case descriptor file contains all the case's metadata, including patient record annotations, hints, and question/answer data. The descriptor file, which must be named meta.json, is written in the JavaScript Object Notation (JSON) format, an open, text-based standard for information interchange, often compared to XML (Holzinger et al. 2001).

The patient records themselves consist of PNG image files, with each patient record consisting of one PNG image. Multiple-page patient records should be rasterized into one continuous image file, which can be panned and scrolled as if it were a long multiple-page document (see the video demonstration described above). Each patient record is also described using the metadata contained in the meta.json descriptor file.

11.4.3 Creating Cases

Currently, cases must be created manually for import into the Casebook application. This is done by first creating a folder containing all the patient records required for the case. There is no requirement for the way in which files are named; however by convention files are named and numbered in the form <department>100.png,

<department>200.png, ..., <department>n00.png to make it more clear which files should appear in which order when being viewed in Windows Explorer or the Mac OS X Finder. This convention also allows for files to be placed in between two existing documents if needed, while preserving file order (e.g., eba150.png would then appear between eba100.png and eba200.png in most file managers).

Files should be in PNG format; however, work is underway to allow for PDF files to be viewed directly, using the iOS API's native PDF support. Although there is no minimum resolution requirement, experience has shown that A4-sized patient records that have been exported at approximately 150 pixels per inch allow for more than adequate zooming, panning, and scaling when viewed using Casebook. In terms of performance, PDFs rasterized at over double this resolution displayed, zoomed, and panned effortlessly on a 2nd-generation iPad 2 and first-generation iPad mini—therefore, no performance issues arise even when zooming and panning very large, high-resolution images. Many freely available tools allow for the conversion of PDF to PNG, such as the ImageMagick multi-platform software suite (see http://www.imagemagick.org/), or Mac OS X's Preview application. Patient records that contain more than one page (see video demonstration described earlier) should be rasterized into one continuous image file containing all pages of the record.

Once a folder has been created containing the relevant patient records, the meta.json file must be written. This is a metadata descriptor file which contains the case's annotations, hints, and question data.

An extract of such a descriptor file is shown below:

```
{
   "filename":"eba100.png",
   "type":"patientRecord",
   "department":"Outpatients",
   "caseDetails":"Details text that appears before
            beginning case.",
   "MesHTerms":"D009203",
   "fileOrder":1,
   "annotations":{
     "annotationHeading":"Sample Annotation",
     "annotationText":"Some annotation text for the
                 file100.png patient record."
   },
   "question": [
       {
         "type":"singleChoice",
         "question":"What is the most likely cause
                 of these symptoms?"
       },
```

```
            {
              "correct":"NO",
              "text":"Answer 1"
            },
            {
              "correct":"YES",
              "text":"Answer 2"
            }
        ]
}
```

As can be seen, the JSON code above describes one patient record, which includes the name of the file (eba100.png) and describes its annotations. The fileOrder parameter is an integer value which describes the order in which the patient record should appear. Questions for a particular patient record are defined within that record's metadata.

Once a folder has been created that contains the relevant patient records and a completed meta.json descriptor file, the folder is zipped and renamed with the extension .case. Once a folder has been bundled as a .case file, it is a self-contained case within a file and it is this file that can be imported into the Casebook application using iTunes.

Obviously, it is not ideal to create patient cases manually. Therefore, a Case Creator desktop application has been proposed to facilitate the task of creating cases. A Java-based application would enable a user to drag and drop previously anonymized patient records into the Case Creator interface, organize them as required—into departments and temporally within each department or section—and allow the user to create questions that appear between patient records. The Case Creator would then generate the corresponding meta.json descriptor file and output an archived case that can subsequently be imported into the Casebook app using iTunes. It is expected that the application be written in Java for the simple reason that it could be used across several operating systems. However, for the purposes of testing and developing the app according to the requirements collected from the literature research described in the previous sections of this report, priority was the development of Casebook itself.

11.4.4 Storing Cases

As described in Sect. 11.2, we believe it is important for teaching institutions to be able to pool cases together, thus allowing for students to view multiple cases of similar patient presentations.

Cases themselves are tagged using MeSH terms. MeSH (Medical Subject Headings) is a controlled vocabulary thesaurus that is used for indexing articles in the National Library of Medicine's PubMed database. Each case can be tagged with MeSH terms which helps to organize them into categories or to aid searching. This is important for creating pools of cases, where cases that deal with similar themes, diseases, or subjects can be grouped together more easily or automatically. The MeSH vocabulary was chosen as it is freely available, is kept up to date, and has a far smaller footprint than other terminologies such as SNOMED. The 2013 ASCII version of MeSH is 28 MB in size and can be downloaded from the MeSH homepage. When creating cases, educators can access the vocabulary using the online MeSH browser (see https://www.nlm.nih.gov/mesh/MBrowser.html) and search for the terms to tag their cases with. The MeSH terms are written into the meta.json descriptor file, along with all other annotations, question data, and so on.

The JSON descriptor format requires both the MeSH Heading and Unique ID be used to tag the cases. For example, a user may wish to tag a case that deals with a patient suffering from the effects of a heart attack with the MeSH Heading *Myocardial Infarction* and the Unique ID *D009203*. For case databases, these MeSH terms could be used to group cases according to MeSH terms—a database of properly tagged cases could easily display any cases that match the ID for myocardial infarction or automatically suggest similar cases depending on previous downloads or search activity (much how PubMed currently behaves when users search for articles).

It would also be possible to create databases of cases that could be accessed via a web-based interface. Cases that are uploaded could be organized according to their MeSH tags and could be searched using MeSH Unique Identifiers or free text by searching each case's MeSH Headings. Being able to properly organize and build pools of cases that concern certain diseases is seen as paramount to the development of the illness scripts described in Sects 11.2 and 11.3.

Cases that have been created can only be transferred to an iPad device using a USB cable and a feature of iTunes known as File Sharing. This is demonstrated in Fig. 11.5. When an iPad device, with Casebook installed on it, is connected to iTunes, the File Sharing tab allows the tutor to drag and drop cases into the application. When the iPad is synced, any selected cases are then transferred to the iPad over USB.

It was a deliberate and intentional design decision to only allow cases to be transferred to the iPad using a USB cable and iTunes, for the simple reason of patient data security. The iOS SDK allows for apps to register themselves as being capable of reading of any particular file format, so that files that are emailed or read over the Internet can be opened by the app. This would make it easier to transfer cases, as they could be emailed to devices. However, email is inherently insecure and many email providers do not support encryption or use SSL or other such security protocols. WiFi networks are also often unencrypted or use older, more easily compromised encryption standards such as WPA (Borisov et al. 2001). Therefore, it is only possible to import cases using iTunes as an interface to the app itself. Files which have been transferred to the iPad device appear in the list of cases, as shown in Fig. 11.1.

Fig. 11.5 Cases can be transferred to an iPad via USB using the iTunes "File Sharing" feature

11.5 Conclusions and Future Work

A number of factors will shape the future work of the Casebook application. There are numerous features which could be included in future versions of the application; it is simply a matter of priority as to which features will be developed first.

Looking into the long term, we plan to create cases that are less linear in structure and more resemble the structure of a flowchart or other such graph-based control-of-flow diagrams. To do so, a description language such as the Oasis Business Process Execution Language (BPEL, see https://www.oasis-open.org/committees/wsbpel/) would need to be implemented. Therefore, choices made by students at certain points throughout a case would lead them to different departments depending on what they have chosen. Currently, when a student has completed a section of a case, the next section displayed to them is predetermined and does not change depending on their answers (see Fig. 11.2a). However, it remains to be seen whether cases can be organized in this dynamic way—for example, it makes little sense to allow a student to view a group of patient records that would precede a required examination. Despite this, it would be possible to dynamically rearrange some sections of a case depending on the choices made by the user. The creation of such dynamic and nonlinear cases would require more thought and longer production times than those in a linear structure, yet they would certainly make students feel more like they are in control of the flow of events.

Short-term features include the possibility of using different types of answering methods, such as free text answers. When working with free text, answers can be evaluated in two ways. The first method would be that tutors manually read all submitted answers and then grade them. The second would involve natural language processing, which has been successfully implemented in the Maryland Virtual Patient (Nirenburg et al. 2009).

Other short-term features will be added to the existing application in order to enhance the user experience. For example, the iOS SDK and APIs are constantly being updated to include new visualization techniques or presentation styles that could be incorporated into the app, such as Collection Views, which make it easier to visualize stacks of objects such as photos, but could be customized to display patient records in groups.

Casebook, in summary, is an application that aims to improve diagnostic reasoning and preparedness by utilizing non-simulated, common, noncomplex, and multiple real-life patient cases within a tablet-based teaching application. The application will be released for free on the Apple App Store upon completion, which will allow other institutions from anywhere in the world to use it within the framework of their current curricular activities. We expect usage scenarios to concentrate on institutions collecting repositories of cases in order to enhance diagnostic reasoning as highlighted in this chapter. However, this is not the only usage scenario for the Casebook system—complex, singular cases could also be used within specialized case-based or problem-based learning seminars.

Patient Data Text data, such as the texts and question data seen in the screenshots, were gathered from The New England Journal of Medicine's Interactive Cases. See http://www.nejm.org/multimedia/interactive-medical-case. Radiology images from the Gamuts in Radiology. See http://gamuts.acr.org/.

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Chapter 12
Mobile Learning in Nursing Education: Lessons Learned

Donna Russell, Paul Steve Gentzler, and Lea Wood

Abstract This chapter provides an overview with related case study research of three programs at the Sinclair School of Nursing at the University of Missouri that are implementing mobile technologies. The programs include the (1) design of an On-Demand Video-Assisted Competencies to implement a training protocol for increasing the effectiveness of training and performance of operating room nurses using mobile technologies, (2) the integration of mobile devices in the Sinclair School of Nursing simulation center to develop both advanced cognitive processes and skills, and (3) the integration of mobile technologies into a Missouri Quality Improvement grant to train advanced practice registered nurses to decrease the rehospitalization of elderly patients in nursing homes. Results of the research identified variances in the effectiveness of the integration of mobile technologies related to (1) the alignment of the characteristics of the technology and the goals for integration, (2) the influence of attitudes and previous experiences of users on the purposefulness of the mobile technologies, (3) the contradictory characteristics of the contexts for the implementation of the mobile technologies, and (4) effect of the change agents driving the design and implementation of the mobile learning technologies.

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R. Huang et al. (eds.), *The New Development of Technology Enhanced Learning: Concept, Research and Best Practices*, Lecture Notes in Educational Technology, DOI 10.1007/978-3-642-38291-8_12, © Springer-Verlag Berlin Heidelberg 2014

Keywords Mobile learning • Nursing education • Interactive design • Evaluative research

12.1 Introduction

This chapter provides an overview with qualitative case study research of three programs implementing mobile technologies at the Sinclair School of Nursing at the University of Missouri at Columbia. These programs include (1) the design of the On-Demand Video-Assisted Competencies (ODVAC) training protocol for increasing the effectiveness of training and performance of operating room (OR) nurses using mobile technologies, (2) the integration of mobile devices in the Sinclair School of Nursing at the University of Missouri at Columbia's Essig Simulation Center (ECSLC) to develop both advanced cognitive processes and performance skills, and (3) the integration of mobile technologies into the Missouri Quality Improvement (MOQI) grant program to train advanced practice registered nurses (APRN) to decrease rehospitalization of patients in nursing homes.

12.1.1 Methodology

Rogers (1995) established a framework that predicts the complex processes by which individuals and organizations adopt new ideas and practices. Rogers theorized that an innovation is an object with perceived attributes that can explain its rate of adoption. Dearing and Meyer (1994) focused their research on the effectiveness with which a change agent communicates those attributes to potential adopters. Furthermore, Moore and Benbasat (1991) suggested it is not the perceptions of using the innovation rather than the perceptions of the innovation itself that are of interest (Jonassen et al. 1999).

Rogers identified the rate of adoption of innovation as a "process through which an individual (or other decision-making unit) passes from first knowledge of an innovation, to forming an attitude toward the innovation, to a decision to adopt or reject, to implementation of the new idea, and to confirmation of this decision" (Rogers 1995, p. 161). Rogers suggested that prior conditions such as previous practice, felt needs and problems, innovativeness, and norms of a social system can influence how an innovation is implemented in an organization. Hall and Hord's (1987) research suggested developing supportive strategies for working with each individual user such as holding ongoing training sessions throughout the implementation effort. They also found that when members of a social system involve themselves in the innovation decision-making process, the integration of the innovation is more successful (Hall and Hord 1987).

This research study is a qualitative case study to understand the implementation of innovative mobile technologies and their productivity in meeting the educational and developmental goals for each project. The study will use cultural historical activity theory (Russell 2004; Engeström et al. 1999) to provide systemic analysis of the design and integration of mobile technologies into a defined work environment for the purpose of developing high level of competencies. Using a multiple case study research method, the researcher will collect and analyze data to:

1. Understand learners' perceptions concerning the integration of the new technologies
2. Understand instructors' and program coordinators' perspectives concerning the integration of the mobile technologies
3. Identify affordances and constraints of the technologies in the context for integration of mobile technologies in relation to the educational goals for the project
4. Describe the educational context and define the influence of the mobile technologies on the educational setting

12.1.2 Methods

In order to define the inherent issues and understand the effectiveness of the integration of mobile technologies in these cases, the researcher, Dr. Russell, developed surveys, collected artifacts, and interviewed the change agents.

1. The researcher surveyed operating room (OR) nurses to understand their perspectives on the potential of the innovation and their previous experiences with technology.
2. The researcher surveyed nursing students in the Sinclair School of Nursing who are using mobile devices in the ECSLC on their attitudes and experiences using mobile technologies.
3. Students in Dr. Laffey's class at the School of Information Science and Learning Technologies (SISTL) at the College of Education at the University of Missouri as part of a class activity developed a response to the problem space of the ODVAC training protocol. They were surveyed to understand their perceptions about designing a new mobile learning technology.
4. The researcher interviewed a coordinator and surveyed two other coordinators and one systems analysis to understand their perceptions of the MOQI mobile technologies project. The interview's purpose is to understand the goals and development of the project.

12.2 On-Demand Video-Assisted Competencies (ODVAC)

12.2.1 Description

This project is the design of a mobile learning protocol to provide timely ongoing performance training for operating room (OR) nurses. The designers created the On-Demand Video-Assisted Competencies Protocol. This training and support protocol will develop a mobile app, an iBook, and an online learning environment to address the training needs of the OR and perioperative nurses. The purpose of this mobile learning protocol is to develop a support protocol in the immediacy of the operating room in response to the highly evolving advanced technologies required for competency in that setting. Dr. Donna Russell, Academic Technology Liaison at the Sinclair School of Nursing, and Steve Gentzler, operating room (OR) nurse, collaborated on the design and development of this project.

The development of a new training protocol for OR nurses called On-Demand Video-Assisted Competencies (ODVAC) based on a need to provide just in time learning experiences for OR nurses that included very defined instruction responsive to the fluid environment of the OR. The design characteristics of ODVAC includes (1) a searchable database of OR technologies, (2) short video clips of experienced nurses describing these technologies and preparing them for use in the OR, (3) ready access through a mobile tablet in the OR, and (4) interactivity including links to online resources. The purpose of this mobile learning performance training protocol is to develop skills in the immediacy of the operating room in response to the rapidly evolving advanced technologies required for competency in that setting.

Successful, timely performance by all surgical team members promotes optimal care delivery both in time and quality for the patient receiving a surgical procedure. Operating room nursing staff members are constantly challenged to demonstrate intraoperative competency with what has become in the past 10–15 years, a quickly changing set of mechanical supplies, electromechanical implements and devices, pieces of equipment, and biomedical supplies (Henneman 2009). It became impossible to keep proficiency in all surgical specialties that OR nurses, RNs, and surgical technicians are required to staff.

Perioperative nurse educators, managers, surgeons, and staff members are seeking ways to meet the performance demands imposed on the peri-/intraoperative area by the rapid advances in surgical technology. Proficient operating room staff members who master the ever-changing array of various procedures, supplies, and equipment could bank their expertise through short video clips readily available "on demand" utilizing mobile technology.

In the OR, mobility is very important because it is more efficient to deal with the issue at the time and place it arises. Surgical team members such as the surgeon, surgical technician, and anesthesiologist are not very mobile, whereas the circulating nurse is by definition moving around the room. It makes sense for the circulating nurse to carry what is needed to facilitate and complete the task. In the surgical procedure process, minimal disruption along with facilitation is optimal. Time is critical to the point of saving a patient's life. Mobile apps currently provide the quickest access to information, as it is needed, to perform optimally for the patient. New technology will bring new opportunities, but staff must be allowed and encouraged to explore possible uses for new devices and applications that meet with the overall goals of the institution. Innovation must be encouraged, given worth, and rewarded.

A professor at the University of Missouri at Columbia's School of Information and Learning Sciences, Dr. Laffey, at the School of Information Science and Learning Technologies (SISLT) incorporated the ODVAC design process into his course, Designing Performance Support Systems. His students developed several models for implementation of mobile technologies for on-demand performance training. Once of the models included a checkout model for a mobile device that would provide OR nurses with an ongoing feedback model for increasing their access and response time to their evolving work needs. This model would include the videos of the technologies used in the OR as well as interactive tools and access to other databases for getting schedules and inputting information on their notes on operations. His students were surveyed to understand their perspectives on the design of the ODVAC performance training protocol.

12.2.2 Research Results

Seventeen experienced OR nurses, ranging from 6 months to more than 5 years of experience, agreed to respond to a survey identifying their perceptions and experiences with technology. The second question asked the OR nurses to identify how they used mobile technologies at work. Approximately half, 47 %, of the nurses used texting and medical apps and accessed the Internet on a mobile device for work. Question three was a Likert matrix asking the OR nurses about their perspectives on the integration of mobile devices in nursing. They were asked to rate their response as (1) strongly agree, (2) agree, (3) neutral, (4) disagree, or (5) strongly disagree. The results are shown in Table 12.1.

The surveys and interview did identify several issues with the integration of mobile technologies among the OR nurses' experiences, perspectives, and beliefs. The majority of nurses who completed the survey were experienced OR nurses. They were evenly divided among those who have used mobile technologies and those who do not. They supported the potential to integrate mobile technologies into their work environment.

Statements related to the OR nurses' perceptions about the future of mobile technologies and their feelings about their competencies were rated as strong positives by the OR nurses with a strongly agree response 70.59 % of the time. The strongly disagree rating, however, was also chosen in 11.76 % of the time. This variance in beliefs among OR nurses is an aspect of integration that should be understood and addressed when designing a training protocol using mobile technologies.

The students were surveyed on the design characteristics of a training protocol for OR nurses that focuses on integrating on-demand mobile technologies. They

Table 12.1 Perceptions

I am very confident of my ability to use new technologies in the OR	1.88
I feel that my training has prepared me for changes in the OR	2.65
I believe that I can problem-solve any situation that I encounter in the OR	2.12
A mobile device can provide me with timely information when I need it in the OR	1.88
I believe that a mobile app designed for my use of technology could be a useful part of my training	1.71
I am confident in my ability to learn using a mobile device	1.65
Short video clips of procedures are a good way to understand OR tools	1.65
I believe the integration of mobile apps can provide timely support for nurses or nursing students	1.59
I believe that the training of nurses can be improved by using interactive online programs including mobile apps	1.76
I believe that nurses will use more mobile devices in their workplace in the future	1.65

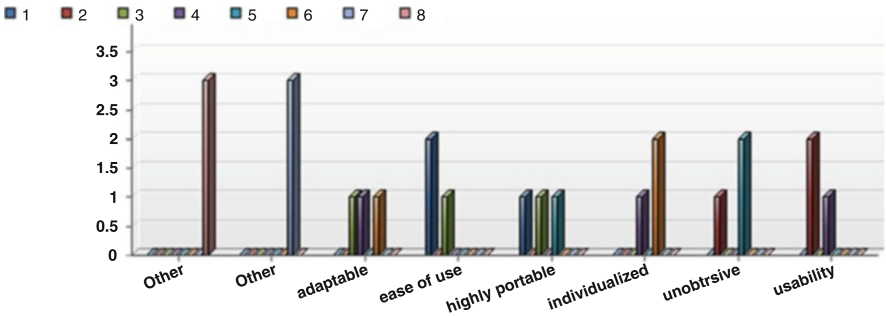

Fig. 12.1 Design issues

were surveyed on design issues they addressed, the critical design features needed to increase functionality, the professional development issues for successful integration, and their ideas on most important design issues to be addressed when developing the ODVAC. Below is their response to the topic of the most important design issues in this project. They ranked these issues from a scale of 1, most important, to 7, least important. The results are shown in Fig. 12.1.

The second question asked them to discuss their ideas about the critical design issues. Below are two of their responses.

"Data architecture: it needs to include all the information needed where it's needed. If the system does not include sufficient information or the information is not accessible in a way that follows user's mental models, the mobile technology could cause more problems than it solves."

"It must have value and meet a need."

The fourth topic asked the students to describe their ideas about the most important aspect of designing a mobile app for nurses in the OR. A response is listed below.

"Accessing equipment-specific or situation-specific information easily"

Finally the students were asked, "What do you consider the most important aspects needed to successfully integrate ODVAC into an OR? Why?" One student noted,

"Getting the design to match nurse's mental models and provide the support needed is the most important. Training may be necessary, but will be less of an issue if the design is intuitive and does what it needs to do."

In response to the surveys, the developers modified their design for the protocol to include multiple features including a report generator that will include a scheduler as well as the on-demand video feature that will be used to access brief training videos for live, on-demand learning of new tools implemented into the OR. This database will be searchable for ease of accessibility and increase functionality. Additionally the on-demand training feature will include the potential to scan the tools and link to the On-Demand Video-Assisted Competencies feature through the QR scan program added to the ODVAC program using the OR nurses' mobile device. The ODVAC will develop an online learning management system that will provide ongoing online support.

12.2.3 Summary

The results identify several critical aspects that reflect the perspectives of the OR nurses and the students. The nurses and the educational technology students both identified design as an aspect of increasing the effectiveness of the integration. The nurses' beliefs that they could use mobile technology is tied to the intuitiveness and purposefulness of the design of the ODVAC protocol using the most salient aspects of mobile technologies to develop effective and efficient on-demand training protocols. These are aspects of defining the meditational effects of the technologies (Russell 2006) and the characteristics of the users implementing the new technologies including the users' perceived value of the innovation focusing on their perceptions of the functionality and usability of the innovation. (Rogers 1995).

12.3 Mobile Use in the Essig Clinical Simulation Learning Center (ECSLC)

This case will describe the integration of iPads into courses using the Essig Clinical Simulation Learning Center (ECSLC) at the Sinclair School of Nursing at the University of Missouri at Columbia. The instructor, Lea Wood, uses the mobile technologies to develop live simulations in the ECSLC to facilitate the development of a high level of problem-solving, critical thinking, and decision-making in

Fig. 12.2 ECSLC skills lab

response to clinical experiences simulations. The Institute of Medicine (IOM) in 2000 discovered that as many as 50,000–100,000 people were dying annually from preventable mistakes such as medication errors, communication breakdown, and equipment failure. IOM made goals to improve patient safety, although carrying out those goals is challenging with the current changes within the health-care setting including a decreased number of nurses available (Strouse 2010). One of the biggest challenges to nursing instructors is translating concepts and theory into practice with in a clinical setting (Griffin-Sobel 2009). Graduate nurses find themselves in job positions where they have little to no experience with that particular clinical setting (Strouse 2010). Simulation provides a secure and protected learning environment for students to develop clinical skills without the risk of patient harm (Henneman 2009). Bearnson and Wilker (2005) validated the efficacy of simulation on nursing students' ability to safely administer medication. Simulation has been shown to bridge the gap between theory and practice (Jeffries 2005) (Fig. 12.2).

The ECSLC includes eight computerized manikins that exhibit symptoms based on programs. The ECSLC has added 10 iPads and 10 iPad minis. The students use the iPads to (1) identify and diagnose, (2) search and retrieve information, and (3) respond to the case assignments. During a live simulation students work in groups and move from one moderate fidelity mannikan to the next as they diagnosis and then respond to each simulated medical event. They are also videotaped during these live events. The students will then go into the computer lab adjacent to the ECSLC and view their videos after their live event for reflection and self-assessment. Finally, they go through the live event again with faculty oversight and assessment. iPads were chosen because of their ease of use and the number of apps available for the nursing students (Johnston 2012; Olin 2011).

Lea Wood is the coordinator of the ECSLC. She developed an educational program and curriculum that utilizes mobile technologies. The following section is her description of her experiences as a result of implementing mobile technologies into her instruction of undergraduate nursing students.

I have a unique approach to this discussion because I am both a student and an instructor. This describes the challenges that led me integrate technology, how I implemented it, and what obstacles I encountered. While I would love to say every innovative idea I implemented was successful, I can't. The truth is utilizing technology is a learning process. Much of it is trial and error.

My first challenge as a new instructor was lecturing to a room of half-closed eyes and texting under the table. It is unreasonable to expect students to sit for hours, passively absorbing material, and expect them to retain it. I decided I needed to keep my students engaged. I needed to make my class interactive. The first change to my course was to implement interactive participation software. I polled my students and discovered that 100 % of them had access to some sort of smart device they could bring to class. I define "smart device" as a laptop, tablet, or smartphone. In addition, I had 20 smart devices available to loan out, should a student have issues with their device or have limited funds. I did some investigating and found a software program that met my goals. With this software I am able to post questions during lecture and have the students answer using their devices. I see their answer immediately, and am then able to gauge if my students understand the material or if I need to revisit the topic.

I teach a nursing skills course, which has a laboratory component in addition to the didactic. In lab, my task is to prepare them for taking care of patients in the real world. Simulation is a tool used to bridge the gap between theory and application of practice. Simulations provide a mock environment where the student participates in a scenario of a real-life situation (Jeffries 2005). Simulation is a concept widely used to train health-care professionals to decrease medical errors and increase the effectiveness of training (Strouse 2010). My goal is to have students that are confident and competent to enter the clinical field. For an in-class simulation, I create a realistic patient scenario based on the content I want the students to learn. At the start of class, I introduce them to the patient and give them everything they need to know to make an initial assessment. I will display a picture of the patient and play audio clips of the heart and lung sounds; I have even been known to spray the room with fragrance. As the class progresses through the case, we stop at critical decision points. By the end of the simulation, each student will have been exposed to the same knowledge and critical thinking points, as they would be in a simulation. The feedback about in-class simulations from the students overall is excellent.

I am constantly trying out new ways to incorporate smart devices into my course. Each generation of students has a higher level of expectation for using technology in their education. My biggest advice for integrating technology into the classroom is to overcome your fear and do it. You don't have to completely overhaul your class in one semester. Start small, make a few changes, and see how they work. Maybe even just integrate one new idea into a single lecture. One tiny change can make all the difference. Use your creativity. The sky is the limit.

Table 12.2 Beliefs about mobile in nursing

Statement	Mean
I believe that the use of mobile technologies is a useful part of my education	2.31
I am confident in my ability to learn using a mobile device	2.23
Mobile apps are useful tools for nursing students	2.31
Mobile apps support learning authentic nursing procedures	2.62
Mobile apps will be used more in the future in the nursing profession	2.15
Mobile apps can help me interact with other students	2.92
I prefer to use a mobile app to access information instead of a laptop or desktop computer	3.23
I feel that I can operate a mobile device proficiently	2.31

12.3.1 Research Results

The research for this project consisted of surveying the nursing students and reviewing the descriptions and curriculum for courses using mobile learning technologies to understand the perspectives of the students and define the effectiveness of the integration of mobile technologies into the ECSLC. Dr. Russell surveyed 13 nursing students who were currently in Lea Wood's course. All of the nursing students were 5th semester students in the nursing program. In their first response, they were asked to rate your educational experiences using mobile devices by rating the statements in Table 12.2 as either (1) strongly agree, (2) agree, (3) undecided, (4) disagree, and (5) strongly disagree.

Next they were asked to write any ideas they have about using mobile technologies in nursing education. Some of their responses are listed below.

"At this point in time, not everyone owns a mobile device with apps or internet access. I think classes and activities should be as sensitive to that as possible while incorporating those tools into teaching. It seems that at a certain point in time, everyone's mobile devices will be that way, but until then it should not hurt someone's ability to participate fully if they do not have their own fancy gadgets."

"Think the new medical apps are very valuable and useful for health professionals, both in the hospital setting and when still in school. They offer quick access to pertinent information without having to look up information in a textbook. As useful as books are, it's much more efficient to have information in the palm of your hand. I think that in the future the use of mobile devices in nursing education should be done more, having nurses look up more information about drugs and dosages and activities in order to become familiar with the apps."

They were asked to describe a learning experience they have had using a mobile device in nursing education. Some of their responses are listed below.

"I used my mobile device to film and upload videos to YouTube that involved me performing skills for a nursing class."

Table 12.3 Mobile use

Statement	Mean
I feel that I will be able to use mobile devices productively as a nurse	1.82
Mobile devices support nurses working collaborative with doctors and patients	2.18
Mobile devices will be integrated into the nursing profession in the future	1.45
Mobile devices should be used ethically in clinical settings	1.36
Mobile apps support my professionalism as a nurse	1.91
Mobile apps will be part of my ongoing educational experiences and training as a nurse	1.82
I am confident in my ability to use mobile devices in nursing	2.09

"We have done simulations where we had to look up certain medications and find their administration guidelines and correctly set up PCA pumps and syringe pumps to their appropriate times. We have also just used mobile app devices for looking up various types of medications to learn exactly what they are and how they work."
"I used it in Skills Lab to watch YouTube videos and look up labs and drip rates."
"Using Medscape (a medical app for the iPad) to look up drug information"
"I used Medscape to research medications."
"Lab values"

They were asked to rate statements about the use of mobile devices in nursing and rate them from 1 strongly agree to 5 strongly disagree. The statements and the mean are shown in Table 12.3.

Finally the students were asked to describe an experience using a mobile device in a clinical setting.

"On one of my clinical days, I nurse was trying to look up a lab value on the Internet and I was there beside her and able to pull up the information faster for her with my mobile device. I have also used my mobile device frequently to look up values to fill out my pre plan paper work"
"Talking on the nursing page on the Facebook app."
"It was a quick and easy way to find information fast especially with all of the apps available that pertain to a certain topic. For example, we used Medscape to look up drug IV rates and compatibility. It is just a reliable way to make sure you are finding the correct information instead of hoping Google has it."

In the ECSLC, Lea implements mobile technologies successfully as an integral aspect of the nursing students' education in order to simulate real-world events. She uses mobile devices to provide opportunities for her nursing students to promote critical decision-making, access information in a timely manner, and disseminate information on the results of their clinical simulations based on her beliefs about the nature of teaching and learning for nursing students (Wiley 2012). She is highly innovative and provides ongoing support for the integration of mobile devices into her classroom. She is an early adopter (Rogers 1995) and her efforts as a change agent provide the impetus for this innovation and for sustaining it to meet her goals for developing the advanced cognitive processes and procedural skills of her students.

12.4 Missouri Quality Initiative for Nursing Homes (MOQI)

The University of Missouri Sinclair School of Nursing to serve as its technical partner on a nearly $15 million grant from the US Department of Health and Human Services Centers for Medicare and Medicaid Services (CMS). The grant award will be applied toward a project to reduce avoidable rehospitalizations of nursing home residents and is one of among only seven awards in the country. This important project aims to improve patient care and lower health-care costs. An alarming statistic is that nearly 1 in 5 Medicare patients who are discharged from a hospital in the USA are readmitted within 30 days at a cost of over $15 billion each year (MedPac, 2007). The Missouri Quality Initiative for Nursing Homes (MOQI) goals are to:

- Reduce the frequency of avoidable hospital admissions and readmissions
- Improve resident health outcomes
- Improve the process of transitioning between in patient hospitals and nursing facilities
- Reduce overall health-care spending without restricting access to care or choice of providers

12.4.1 Research

The researcher interviewed a coordinator of the MOQI program and surveyed two coordinators and the School of Nursing's IT analyst. The survey results are described below. The two coordinators' responses are listed first with the IT Specialist's responses following.

What are the educational goals for the MOQI program?

"The APRNs did not have experience in long-term goal. They needed content related to the long-term care environment, systems, and care of older adults. Additionally, they needed information about the INTERACT III program, including procedures, and tools."

"To provide educational efforts that facilitates integration of the APRN into the nursing home setting with the goal to reduce avoidable hospitalizations."

Why did you choose a mobile technology for this program?

"The nurses needed flexible technology they could take with them. The Surface tablet is 'hybrid' that has The Office Suite. Finally, physical space is limited in the nursing homes."

"To facilitate that the APRNs can access Blackboard and Collaborate Live, our educational platforms."

"I made recommendation concerning which tablet to purchase."

What were some of the issues you experienced integrating the mobile devices?

"The mobile device has been successful, however, the challenge for some APRNs has been limited wireless access while in the nursing homes. It depends on the nursing homes. There are problems with connectivity, availability of WiFi. There are dead spots in the homes where neither phone nor tablet works. User error, particularly with Blackboard. They were not familiar with Blackboard and some were not willing to take the time to learn the technology. In this population of learners (older) who must prepare that they are not comfortable with technology and will need a lot of support to work with it easily. If they can't work with the technology at all, it is a red flag that they may not be able to do the job. You just need to plan for technology taking a lot of time."

"Assure Internet access is widely available within the setting where the mobile devices are used."

"Get the accidental damage warranty option"

Dr. Russell conducted an hour-long interview with one of the project coordinators. She responded to the same general issues including:

1. What are the learning goals for the program?
2. Why did you choose a mobile technology for your program?
3. What was the mobile technology you chose and why? And
4. What are the issues you experienced integration mobile devices?

A transcript of the interview is below.

This is a large multiyear grant for 14.8 million is a difficult process to coordinate. It includes multiple collaborators in 16 nursing home, most of which are in St. Louis, Missouri, approximately 90 miles away. It is her role to ensure that the monies are spent in the most cost-effective manner. There are multiple goals for the program including (1) the reduction of hospitalization of patients in nursing homes by supporting nursing home employees improve their early identification of nursing patients. Hospitalization can initiate a cycle of mental and physical decline in nursing home patients. (2) Reduce the prescription of anti-psychotic medications. Patients are misdiagnosed as psychotic resulting from dementia or other medical conditions. These medications also reduce the life expectancy of the patients and (3) increase the completion of advanced directives. An advanced directive is the instructions for your end-of-life experience. The program integrates APRN nurses to be located in the participating nursing homes. These advanced nurses will train and respond to the nursing home nurses and staff in regard to the three goals listed above.

One of the coordinators is very knowledgeable about technology and suggested a mobile device for the APRNs and nursing home nurses to facilitate their communication with the faculty and increasing access to the learning management system that was designed to coordinate the training program. As many medical facilities are moving to Electronic Medical Records the inclusion of this technology facilitates meeting their educational goals. One of the major aspects for the communication is a process called "Direct Mail" that allows the nurses to stay in contact with the faculty in Columbia at the University of Missouri Sinclair School of Nursing. The main issues are how to develop a protocol for this process that is compliant with HIPPA (the US Federal law that prohibits sharing medical information). This protocol has not been developed and will have to be designed into the training program for the nurses.

There were several decisions concerning the integration of the mobile technology. The mobile tablet they chose was the new Surface tablet that is a hybrid tablet running both as a mobile device and as a computer using Windows 8. They felt that they could train the nurses more readily since the tablet could be used as both formats. However, the tablet runs Windows 8 that is a new operating system and their previous experiences running Windows in previous versions did not transfer readily. Additionally this new Microsoft tablet was expensive, costing $1,000 that reduced their grant budget significantly.

One of the major reasons for implementing the mobile device was for ready access to communicate, check records and add information to records. All of this requires an Internet hook up. The mobile tablets they chose are WiFi only. They could not pay for access to the local networks considering it too expensive. This means that the tablet will only access the Internet when in a WiFi space. Some of the nursing homes do not have WiFi access. In this case, it was very difficult for the nurses to use the device while on the job. Eventually the coordinators purchased the nurses a cell phone for ongoing communication with them. They will work with the nursing home to improve their wireless access. Many of the documents needed to share with doctors, the faculty and other nurses have to be scanned as they are printed out. There is no way for the mobile tablet to scan and send these documents. This is a significant problem for communication among the collaborators in the program.

Additionally the nursing homes have been resistant to implementing the mobile technologies. Administrators are afraid the tablets will get broken or stolen. They are also concerned about HIPPA violations and staff surfing the Internet during work hours.

The nurses themselves were unable or unwilling to give the time for training to learn to use the mobile technologies. They overestimated the nurses' technology skills. They felt that they could use a tablet excel and send a file.

According to the coordinator, this was the most complex difficult project she has ever done. The level of complexity was raised by the addition of new technologies. There is an incredible amount of stress involved in implementing new technologies. The technologies themselves require many hours of trouble shooting, training and there are ongoing considerations about the ramifications of using these new technologies. She noted that it is very difficult to change the culture of the nursing home in her role as a change agent to implement the grant successfully implementing mobile technologies.

The concept of integration of mobile devices was to give a nurse a tablet so he/she can walk through the building and access patient information, send information, and update reports which is an ultimate goal. However, she noted that a laptop with a printer-scanner would have been more productive.

12.4.2 Summary

This complex project has a multiple of issues. Some are common to the previous cases concerning the integration of technologies into nursing education (Pilcher and Bedford 2011) and some are unique to this project. This is a large implementation project and this complexity is accentuated by the addition of a newly released technology. This combining of innovations raised the complexity of the implementation and has been previously identified in research as an innovation cluster (Russell 2005). This concept identifies the multiple issues that arise in context when an innovative technology is integrated into a system. Understanding and addressing these correlating issues during design and formatively during implementation can increase the potential for the integration of the new technology. In this case, more time should be scheduled for training of the users of the mobile devices and the additional time needed for the change agents, the project coordinators, to implement the changes.

12.5 Conclusions

In these cases, new technology has characteristics that must be considered when purchased and implemented. The decision to not use a network ready tablet meant that the program is now tied to the Internet access in the nursing homes. In the MOQI case, technologies in place or the lack of technologies in place, e.g., no WiFi in the nursing homes, impacted the integration of the mobile technologies. The decision to use a hybrid tablet to increase transfer of previous computer knowledge would reduce training time, but the new tablet uses a new operating system that was not familiar to the participants.

However, as noted in all cases, functionality, ease of use, and access are common issues addressed by Jim Laffey's students, the nursing students, and the OR nurses and in both Steve's and Lea's concerns for designing and implementing mobile learning technologies, respectively. This matches previous research in innovation including Roger's definitive studies on the characteristics including what is beneficial for implementation, affordances, and those aspects that have higher levels of difficulty for implementation, constraints, of innovative technologies related to the effectiveness (1995). It is important to consider both aspects when designing and implementing a new technology. The benefits of integration should be weighed against the costs of implementation.

The attitudes and background of the users was an issue identified in each case, sometimes in positive ways as in the case of the ECSLC students and in negative ways as in the ODVAC and MOQI project. As a result of interviewing the instructor and surveying the OR nurses and ECSLC students, commonalities among the nursing students and the OR nurses were identified. Both felt they were able and would be able in the future to integrate mobile technologies successfully. Both felt that mobile technologies will be an aspect of nursing in the future. However the ECSLC nursing students' had more experience and higher expectations for the use of mobile technologies in nursing. This lack of experience and related confidence was a greater issue in the MOQI case as the nurses had less background and require more training on the use of the mobile technologies to successfully implement them into their workplace.

In all cases, the innovators described emotional and work stress including increased time to design and implement the innovation and dealing with the issues as the innovation cluster was implemented. In these cases of innovative design and implementation, the implementation of innovation requires a change agent who drives the innovation forward. This is an issue between division of labor and the development of the object as change agents are an aspect of the labor needed to develop the object successfully. Any unresolved contradictions in this critical role of the change agents will reduce the successful integration of the new technologies. In the CSLC, Lea's ongoing persistence on moving forward with the integration of these new technologies is a critical factor in the success of that program. In the MOQI case, the change agents, the coordinators are dealing with contradiction in their roles implementing the innovation. The critical role of the change agent (Rogers 1995) must be considered during design and implementation including how to integrate support systems for the change agents including collaborative forums, training on needed communication forums to support their role of implementing change and developing new concepts of their critical role in the success of the program.

Understanding rules, such as HIPPA regulations, are critically important to the development of the program goals (Russell 2009). In the case of ODVAC, the rules against mobile use in hospitals are considered. In the successful integration in the ECSLC, these context issues are addressed such as identifying the rules concerning access to mobile devices in nursing education and the nursing profession. The research identified a contradiction between the administrators of some of the nursing homes and the integration of new technologies. This contradiction has to be resolved for the project to move forward.

The integration of mobile technologies in the educational or training environment of nurses has the potential to radically changes the nature of the both the learning experience and the training of nurses (Faas 2012). In the ECSLC this was understood during design and implementation and has been addressed successfully, although with great effort, by the instructor, the administrators, the technology specialists, and the nursing faculty through curriculum redesign, purchase, and integration of the new technologies into the ECSLC and many hours working with the technology itself. The resolution of past and ongoing contradictions is an ongoing process that is addressed, at this time in implementation, through ongoing communication, collaboration, and personal emphasis on the integration process.

In the cases of the ODVAC and MOQI, the identification of the users' previous experiences with technology and providing ongoing training and support would ease the anxiety of the users, create a common awareness of the goals of the integration of the technology, and result in the productive integration of the technologies.

Previous research on innovation has shown that the identification of the characteristics of the change agents as early adopters is an important factor to understanding the implementation of new technologies. As Rogers (1995) suggested, “It is often one thing for an individual to decide to adopt a new idea, but quite a different thing to put the innovation into use” (p. 173). Lea, Steve, and the MOQI coordinators as early adopters can define their role through open communication with the nurses and nursing students as well as providing them with support in their roles as innovators. Research has shown that a collaborative understanding of the purpose of the innovation supports the development of the object of this program (Russell 2005). Change agents in these programs are innovators, early adopters, designers and motivators. Within these multiple roles they influence the success of the innovation in multiple subtle ways. Developing their self-awareness of their roles through collaborative forums, increasing awareness of their critical role in implementing change, and training in the development of communication strategies will benefit the programs (Russell and Schneiderheinze 2005).

In these cases, the mobile technologies caused resolved and unresolved contradictions between the nurses, the context and the coordinators themselves. Understanding that new technologies will cause this rippling effect of dissonance in the system is important as a design and implementation process that can be built into the project. In the process of design and the evaluation of implementation of innovations in nursing education, consideration of interrelated innovation clusters should be considered including the perceptions of all participants, the context issues, and the characteristics of the new technologies themselves. All of the projects had the goal of increasing the efficiently and effectiveness of the nurses or nursing students with the potential outcome of improving patient care. Identification of contradictory issues and responding to these issues by resolving them will exponentially influence the potential success of the programs (Russell 2009).

The implementation of mobile technologies in nursing education has incredible potential to transform nursing education and significantly improve patient care in the USA. Understanding the characteristics of innovation and the purposefulness of the change process (Wertsch 1991) and communicating these aspects to all the participants can identify and offset the inevitable contradictory issues that will arise and have the potential to benefit these nursing education programs as well as the health-care system in the USA.

Acknowledgments I would like to acknowledge the students in my class, Computer-Mediated Instruction/Learning in the Educational Psychology department of the School of Social and Behavioral Sciences at Capella University. Their discussions and the identification of issues relevant to the integration of mobile technologies were very valuable resources as I developed and implemented the research for this chapter.

I also wanted to thank the students in Dr. Laffey’s Designing Performance Support Systems at the School of Information Science and Learning Technologies in the College of Education at the University of Missouri at Columbia. Their discussions and design concepts resulting from their study of the design of the ODVAC protocol were both creative and purposeful.

Finally I would like to thank all the students, faculty, and nurses who responded to my request for participation in the study. Their insight and expertise provided a solid base for the development of new concepts about the integration of mobile learning technologies in nursing education.

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Chapter 13
Pedagogical and Organisational Issues in the Campaign for IT Literacy Through Spoken Tutorials

Kannan M. Moudgalya

Abstract This chapter describes an IT literacy promotion drive in India, using Spoken Tutorials, offered through organised self-learning workshops. Spoken Tutorials are Screencast videos of 10-min duration. The steps taken to make the Spoken Tutorials suitable for self-learning are described. As the Spoken Tutorial activity is restricted to open-source software, practice-based learning is possible, thereby being as effective as active learning. Only the spoken part of these tutorials is dubbed into Indian languages, benefiting a large number of students who are weak in English, which is nevertheless widely spoken in India. This helps everyone learn important IT topics while retaining the employment potential. About 100,000 students are trained every year through this methodology, with an option to earn certificates on passing online tests, all of which are offered absolutely free of cost. The website http://spoken-tutorial.org, which is used for coordination, has become extremely popular, with the number of page views expected to be three to four million in the current year. Feedback from 25,000 students and testimonials vouch for the usefulness of the Spoken Tutorial methodology.

Abbreviations

FOSS:	Free and Open Source Software
IGNOU:	Indira Gandhi National Open University
IT:	Information Technology
SELF Workshop:	Spoken tutorial based Education and Learning through Free FOSS study Workshop
ST:	Spoken Tutorial
STs:	Spoken Tutorials

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R. Huang et al. (eds.), *The New Development of Technology Enhanced Learning: Concept, Research and Best Practices*, Lecture Notes in Educational Technology, DOI 10.1007/978-3-642-38291-8_13, © Springer-Verlag Berlin Heidelberg 2014

13.1 Introduction

In this work, we give an account of the steps taken to spread IT literacy in India through Spoken Tutorials (STs) (Moudgalya 2009, 2011a, 2013; Spoken Tutorial Project). This work has been undertaken to improve the employment potential in India. We have the following reasons to undertake this activity: The education sector in India is undergoing a crisis. While there are attempts to increase the Gross Enrollment Ratio, the number of people who can be employed is abysmally low, according to a McKinsey report (Farrell et al. 2005). One of the reasons for this deplorable situation is the shortage of good quality teachers (Moudgalya et al. 2008). On the other hand, in spite of the economic slowdown, industry experts report a large shortage of trained people, especially in the IT sector (Geron 2013). The Spoken Tutorial (ST) project is funded by the Ministry of Human Resource Development of the Government of India to improve the IT literacy of Indian students, so as to improve their employment potential.

In areas of activity-based learning, there is sufficient reason to believe that computer-aided instructions may be as effective as traditional, in-person instructions (Koufogiannakis and Wiebe 2006). This makes a compelling case to use computer-aided instructions when the quality of teachers is wanting. Screencast-based tutorials have effectively been used in various fields (Mohorovičić 2012). Moseley (2013) explains the many benefits of using the instructional material created using Screencast.

An ST is an audio-video instructional material *created for self-learning* through the Screencast technology. The objectives of the ST effort are:

1. To create documentation for Free and Open Source Software (FOSS). Restriction to FOSS promotes active learning, along with other benefits. In a typical Spoken Tutorial of 10-min duration, there are about 100 screen transitions. It is a lot more difficult to create an equally effective PDF document using screenshots. Generally, the Screencasts are known to be more effective to understand a new topic (Novaković et al. 2013).
2. To make every ST suitable for self-learning, given that there is a big shortage of good teachers in India.
3. To conduct workshops using ST, so as to make it easy for students to access the instructional material.
4. To make IT literacy training accessible to students weak in English, without affecting their employment potential.
5. To come up with a mechanism to conduct tests for the participants of ST-based workshops and to issue certificates to the passing students.

All of the above should be made available free of cost to the learners. We will now discuss how we went about to achieve these objectives in the above list while highlighting the pedagogical issues.

13.2 Content Creation

Standard guidelines to create good Screencasts are available (ST Team; Moseley 2013). Creating content suitable for self-learning, when the target audience is large and disparate, is a more difficult task, requiring meticulous planning and adhering to strict guidelines. In this section, we discuss the issues in the creation of outline, script, recording, translation and dubbing in the ST methodology. We also discuss the process of novice check that we have introduced to achieve our objective.

13.2.1 Outline

STs should be classified in a convenient way, for example, as beginner, intermediate and expert. We insist on an outline before one embarks on creation of STs. Outline for each tutorial should be presented in approximately ten bullet points. We recommend an *overview tutorial* for each classification, in general, and the beginner level, in particular. We recommend that the overview tutorial be created after creating the constituent tutorials, although the learner will watch them in the reverse order. This helps ensure that the overview tutorial also is activity based, as explained in Sect. 13.2.2.

The target content should be chunked into STs of 10-min duration, chosen to address the issue of short attention span. The reason why it is not made shorter is to minimise the fraction of overheads in each tutorial, such as information about our project, whom to contact to organise workshops, etc., which are useful to a person who happens to watch just one tutorial. Although Guo (2013) recommends an optimal video length to be of 6 min, the attention seems to be about the same up to 9 min in their study. Restricting the length to 10 min forces the creator to be focused and to cut out the unnecessary information. A procedure to estimate the length of a tutorial is given in Sect. 13.2.2.

The STs should be organised so as to avoid repetition and to ensure smooth flow without having to go back and forth. We insist on a few examples to run through the tutorials. We encourage the files created in a tutorial, if any, to be used in subsequent tutorial and be made available to the users through our web interface, as explained in Sect. 13.3.7.

13.2.2 Script

We require a script to be written before creating a tutorial as it provides many advantages: If a section of the tutorial has to be improved, one can rewrite the script and record it. On the basis of a script, a novice can decide whether they can reproduce all the described actions. It is possible to stream this script when a tutorial is played back, helping students weak in English (Mitterer and McQueen 2009) and the hearing impaired. It is useful to search for key terms. If timing of the script is available, one may quickly locate the required part of a video during the recall stage, thereby addressing one of the shortcomings of Screencasts (Novaković et al. 2013). Finally, it makes translation and dubbing easy, as explained in Sect. 13.2.7.

The objectives of a tutorial should be stated at the beginning. The version of the software and the underlying operating system should be stated. Explicitly stating the prerequisite tutorials, if any, although useful, will hard code the requirement and will call for changes if other tutorials are modified, merged, split or deleted. Because of this reason, prerequisite tutorials are mentioned in our web page only.

All sentences should be easy and short to be accessible to the novice and to those who are not fluent in English. We recommend that most sentences be less than 60 characters long. We insist that no sentence exceeds 80 characters. We refer to this as the 60/80 rule. By restricting the length of sentences, we enforce simple and short sentence constructs. Shorter sentences reduce the temporal contiguity effect, thereby improving the learning process (Mayer and Moreno 2003). Another benefit of this restriction accrues during translation and dubbing, as explained in Sect. 13.2.7.

We have a requirement that unless an activity is described earlier in the tutorial or in one of the prerequisite tutorials, it should be stated explicitly. For example, before a button is pressed, we recommend a script of the following type: *Click the button in the bottom right, circular in shape and blue in colour*. In addition to explaining well, this statement allows more time for a beginner to locate the focus area easily. To ensure that this does not become boring, we require that such a detailed instruction appears only once for any topic.

We also encourage the explanation of every activity in detail. For example, we have a rule that the following type of script be avoided: *Go there, click this, etc.* Instead, it should be explained as in the following statement: *Go to top left-hand corner, click file and then menu*.

Checking the mouse or hitting the *enter* key has to be stated explicitly, as novice users often get stuck on these. Moreover, these do not take much time to state: *Click the mouse* or *hit enter*.

Menu items should be stated exactly as they appear in the screen. For example, if the software has `File browse` as a menu item, the script should not address it as `File view`. Although these two have the same meaning, it will slow down the user.

Active voice should be used in preference to passive voice. Direct order of actions should be used. For example, one should not say the following reverse order of actions: *Let us select file from the media option in the main menu*. Direct order also makes the sentences shorter. In addition to giving examples to illustrate an idea, we also encourage the inclusion of common mistakes and a way to address them. Finally, we encourage the scriptwriter to subject every sentence to *Telephone Test*.

We insist that all STs are activity based. About 75–80 % of the tutorial should be demonstration based that a learner can practise simultaneously. The reason is that if there is too much theory, a self-learner at a remote centre may not get any help if they have a doubt. Because of our FOSS restriction, every user can get the benefit of active learning through the side by side method; see Fig. 13.1.

We recommend that theory, if any, follow the activities mentioned above. For example, after explaining how to write a letter through a series of steps, one can

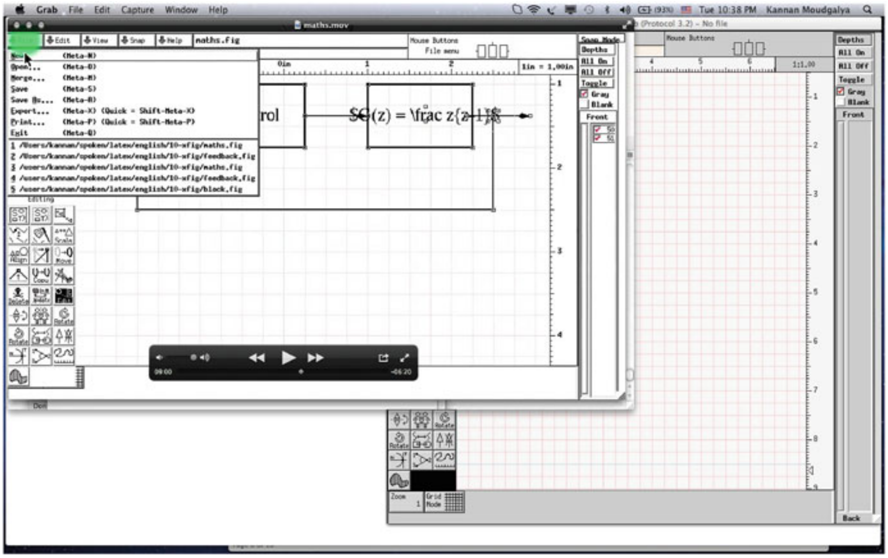

Fig. 13.1 ST on the FOSS system Xfig is on the *left-hand side*, with the Xfig software itself on the *right-hand side*, both in a reduced and in an unmaximised size. We recommend the learner to listen to a command, pause the video and try it out on the software. As the STs are available for free and we work with only FOSS, this approach is possible for everyone

state the benefits of such an activity: *This is called a letter. A letter is useful to apply for leave, job application, etc.* This goes against the conventional method of presenting the theory first and then demonstrating it through examples or activities.

The 75–80 % rule mentioned above may be difficult to enforce in the first tutorial, however, because one would normally explain the features of a software – there is nothing to practise there. We take care of this through an *Overview Tutorial* that explains subsequent tutorials; see Sect. 13.2.1. If the learner wishes, they can see and practise the latter while going through the former.

We now comment on how the length of an ST is estimated. The script writer reads out aloud the script, without carrying out the indicated activities, and notes down the time required to do this. This time duration is multiplied by a factor to estimate the length of the ST. A typical estimate of this factor is 1.5.

13.2.3 Processes to Ensure Suitability for Self-Learning

We rely on the following steps to make ST suitable for self-learning:

1. Our guidelines to create ST, which are similar to the ones described in Moseley (2013), are given in the following format (ST Team): (1) what the guideline is, (2) why this guideline has been suggested and (3) what will happen if that guideline is not followed.

To ensure that the readers read and understood our rules, we conduct a test based on these guidelines. Only those who score above 75 % in this test are allowed to create STs for us. Those who fail in this test have to wait for 2 weeks before taking the test again. This waiting period forces one to learn the guidelines well before attempting the test and it is a standard practice in learner permit tests.

2. We conduct a novice check of every script before recording it. The details of this step are given in Sect. 13.2.4.
3. The STs go through several rounds of admin review, user review and expert review and corresponding revisions.
4. We conduct pilot workshops to get feedback from a large number of users. Recreation of the STs are required if there are major flaws.
5. Finally, we come up with an instruction sheet for every topic. The details of why an instruction sheet is useful and how it is arrived at are given in Sect. 13.3.3.

13.2.4 Novice Check

To ensure the suitability for self-learning, we enforce a *novice check* on scripts before creating STs. A novice check allows a beginner to verify whether they can reproduce every step of the tutorial. If a script passes a novice check, it is permitted to be recorded, else, it is sent for improvement.

At the beginning of our work, we were worried that the STs would end up boring because of detailed explanation of each and every thing. Fortunately, when asked to rate how interesting the STs were, the following numbers of population reported in Table 13.1 responded as very bad, bad, fair, good and very good, respectively: 182, 440, 4,241, 12,073 and 8,140.

Most of the people who undergo our workshops are beginners, as can be seen in Sect. 13.4. Novice check ensures that STs are accessible to our clientele, resulting in many of them becoming experts, one of the objectives of the ST project.

One who does novice check learns to use the underlying software. As we give an honorarium to do a novice check, we must be the only project that pays beginners to learn. More importantly, we give respectability to a novice.

13.2.5 Recording

Using the visual cue and the narration given in the script, recording has to be done, by speaking aloud at a correct speed. To a question whether our tutorials are of correct speed, 504 of the population described in Table 13.1 think that it is slow, 23,185 think that it is of appropriate speed and 1,387 think that it is fast.

In order that everyone can participate in the creation process, we restrict the recording software to FOSS. For the same reason, we do not insist on high-quality, soundproof, recording studios for recording. We have guidelines that everyone can follow to obtain good recording in normal environments: *Close the doors and the*

Table 13.1 Sample distribution: number of girls and boys who gave their feedback state-wise (*left*) and FOSS-wise (*right*)

State	Girls	Boys
Andhra Pradesh	765	1, 035
Arunachal Pradesh	13	26
Assam	2	7
Bihar	17	7
Chhattisgarh	208	165
Delhi	85	152
Goa	31	37
Gujarat	2, 421	2, 991
Haryana	356	533
Himachal Pradesh	60	120
Jammu and Kashmir	17	35
Jharkhand	11	41
Karnataka	611	760
Kerala	287	185
Madhya Pradesh	948	955
Maharashtra	1, 827	2, 090
Manipur	0	4
Meghalaya	52	0
Mizoram	3	3
Orissa	55	112
Pondicherry	103	78
Punjab	327	272
Rajasthan	524	688
Sikkim	1	6
Tamil Nadu	2, 173	1, 670
Tripura	34	73
Uttar Pradesh	756	773
Uttarakhand	40	33
West Bengal	200	298
Total	11, 927	13, 149
FOSS	Girls	Boys
Advanced C++	25	27
C and C++	3, 102	3, 744
Java	1, 050	994
Java Business Application	6	4
KTurtle	14	9
LaTeX	525	460
LibreOffice Suite Base	3	1
LibreOffice Suite Writer	6	35
Linux	2, 978	2, 636
Linux Ubuntu	690	570
NetBeans	10	7

(continued)

Table 13.1 (continued)

FOSS	Girls	Boys
OpenFOAM	6	17
PHP and MySQL	1, 978	2, 624
Python	441	448
Scilab	1, 093	1, 572
Spoken Tutorial Technology	0	1
Total	11, 927	13, 149

windows; remove the battery charger; turn off the fans; turn off the mobile phone – it is not enough if you keep it in silent mode, etc. Such an egalitarian method is recommended for collaborative content creation in general (Schleicher et al. 2013).

We recommend that a tutorial be recorded in one sitting to ensure uniform tone is maintained. In case a mistake happens in the middle of a sentence, we suggest that the whole sentence be re-recorded to make editing easy.

The recording dimensions of our tutorial are 800 × 600. This helps the ST readable in the side by side method shown in Fig. 13.1 or in low-cost tablets, such as Aakash (Moudgalya et al. 2013). If instead, one records an entire screen and shrinks it a lot to watch it, letters in the ST may become too small to read. For the same reason, we recommend a minimum font size of 28 pt, whenever possible in all typing, on editor and console; the cursor or mouse pointer also has to be enlarged (ST Team).

We suggest that the recording speed be about 4–5 frames per second to keep the recorded file size small. Keeping the frame rate small does not affect most of our tutorials, as we generally do not have fast moving content. The average size of an ST is less than 1 MB per minute.

13.2.6 Rescripting and Timing

After recording, editing, revision, etc., we freeze the recording. At this point, the script is modified to match the spoken sentences, as it is not always possible to speak exactly what is said in the script. We also permit minor changes to the script for dubbing purposes, provided the modified sentence is no longer than the original sentence. This can take care of minor mistakes and unclear explanation, if any. At this point, we freeze the script.

Once the script is frozen, we note the time when each sentence starts. A script in which the visual cue has been replaced by timing information is called the *timed script*, which is useful in many ways:

1. Including the time when a sentence begins can act as a *tag* for video players that can start a video from a selected point. This will allow the learners to go through the script and quickly come to the location they want to see.

2. One can scroll the script while streaming the ST. This may be useful to the hearing impaired or to ensure better understanding (Mitterer and McQueen 2009).
3. This facility is useful for dubbing purposes, as explained in Sect. 13.2.7. We need to get timed script of the original only once, irrespective of the number of languages in which we do the dubbing. This is extremely useful for countries, such as India, that have many languages.

13.2.7 Translation and Dubbing

We dub the spoken part of an ST into all Indian languages, while the video remains in English. We do not allow the original video to be changed. This requires that the dubbed sentences fit within the time taken by English, known as the *available time*. The 60/80 character rule in Sect. 13.2.2 that helps enforce simple English sentences in the original video helps fit the translation into the available time, irrespective of the target language. If on the other hand we permit complex sentences, it is not clear whether the time constraint requirement will be fulfilled. Even after the 60/80 rule, if a translation does not fit into the available time, we allow dropping of words that are not vital. As the spoken instructions are supported by a detailed video (see Sect. 13.2.2), approximations in a few sentences do not create much difficulty. Finally, the sentences spoken without any screen activity can be combined for timing purposes.

The main objective of the dubbing exercise is to teach IT skills to children who are weak in English. This allows us to make concessions while translating: dropping of unimportant words, approximating translation, mixing of words from other languages, etc. This allows us to choose a simple to understand translation amongst all the possibilities. If instead, we had chosen the objective of our work as the promotion of local languages, we could not have taken these liberties. We also recommend that the technical words be not translated. This is to increase the acceptance of learners of ST in the IT industry. When local language equivalents are popular, we use both English and local language versions. We accommodate such explanations in the *instruction sheet*, to be explained in Sect. 13.3.3.

If we allow the original video to be changed at the time of translation, the work can increase enormously: The pedagogy has to be checked again, pilot workshops have to be repeated, etc. Dubbing only the spoken sentences allows us to create an equivalent audio and to stitch with the original video. It takes only about 5 % effort to create a dubbed tutorial using the methods mentioned here, compared to the creation of a original tutorial.

Dubbing involves reading out the translation, with a small gap between sentences and recording the audio, using a software, such as *audacity* (Audacity). We recommend that recording be done in one sitting to ensure consistency of the tone between different parts of the recording. To complete the dubbing, we just have to cut and slide each sentence to the correct time in the timed script, explained in

Sect. 13.2.6. In some audio recording software, we have to begin this audio editing from the last sentence and go backwards.

Our approach of one video and different audio recordings helps store STs in an efficient manner. This should also help if any sentence in the original video has to be changed, either to correct a mistake or when the version of the target software undergoes a major change.

Getting training in English video helps the learners get jobs in the IT industry, including in transnational companies. Given that most Indians have some exposure of English, this does not create difficulties even if one is weak in it. This also allows students to use the commonly available computer systems, software and keyboards. Carrying out everything in a local language calls for alternate, often more expensive, solutions.

Translation work has to be done by mature people who understand the objective of translation, namely, to help teach children who are not comfortable in English, often from poor families and from rural areas. Professional translators often insist on exact translation and refuse to use foreign words, even if the translated sentences are difficult to understand or longer than the original sentences.

While translation has to be done by mature people, dubbing can easily be done by younger people, often students. The latter group is more comfortable about the underlying technologies, such as audio recording, changing the locations of sentences and stitching this audio with the original video.

A person who dubs a tutorial is required to read out the translated script first and familiarise themselves with unusual or hard to pronounce words. They should also ensure that all translated sentences can be narrated in the available time. If any translated sentence does not fit into the available time, they should not speak that sentence faster. Instead, they should contact the translator and ask them to rephrase the sentences. They should do the same if it is difficult to understand any translated sentence. Unfortunately, the dubbing people, who are often younger than the translators, do not carry out this important exercise, resulting in the following difficulties: (i) The audio-video sync gets affected. (ii) Audio-video sync is maintained, but some sentence narrations are faster than the rest of the script. We were forced to withdraw many dubbed tutorials in the past because of this difficulty. Checking the audio-video sync can be automated, but it is not clear whether a change in speed can be detected automatically.

The method outlined in this section has also helped us dub popular ST like instructional material created by others into our languages, including in *Indian English* (Alex; Rolf. Steinort).

13.3 Using Spoken Tutorials

Recent studies have shown that Screencasts are beneficial when students use them and also perceive them to be useful (Green et al. 2012). This motivates us to conduct workshops, even though the STs are already suitable for self-learning. We detail our approach in this section.

13.3.1 Side by Side Method to Use Spoken Tutorials

An ST can be thought of as a demonstration of a series of commands. The learner should open the ST in a reduced size and open the corresponding software side by side and practise; see Fig. 13.1.

Because we restrict to only FOSS systems and because the STs are available for free download, this is always possible.

The method suggested above is supported by educational psychology research. In a classic paper, Chandler and Sweller (1991) assert that one should keep the cognitive load low for effective learning. The mental load will definitely be higher if a learner does not follow the method suggested in Fig. 13.1, but watches an ST in a full-screen mode and then switches to the software to try out the commands. Hegarty and Just (1989) have shown that the learning objects should be kept side by side to reduce the eye movement, thereby improving the learning effectiveness. In another classic paper, Mayer and Moreno (2003) argue that as the size of working memory is small, one should put less load on it. If a beginner does not follow the method suggested in Fig. 13.1 and hence has to change the screen after every instruction, the load on the working memory is indeed high.

Two senior professors in an engineering college who underwent an ST-based workshop on LaTeX have the following to say about this method:

> The way Prof. Kannan teaches is excellent. Hands-on practice is important. In the side by side method, we listen to the video and practise. This method is useful and efficient for beginners...
> *Prof. Kavita Thakur, Dept. of Electrical Engineering, Govt. College of Engineering, Amravati*

> Being a person from Civil Engineering, I always had a phobia that all learning using technology methods are for IT experts. But this course broke down this notion. You brought all the required technology on my PC and laptop and these Spoken Tutorials are as if I have my teacher with me round the clock to help me learn...
> *Prof. Kshitiza Kadam, Dept. of Civil Engineering, Govt. College of Engineering, Amravati*

As working with maximised screens has become a norm nowadays, especially in MS Windows-based systems, most people are not familiar with reduced screens that are neither maximised nor minimised. We refer to such reduced screens as *unmaximised* screens. Use of maximised screens was possibly justified in early days of PCs when the screen size was small. Given that larger-sized screens are available, it is easy to follow the suggested method. The guidelines on font, cursor size, etc., explained in Sect. 13.2.5 and in ST Team, ensure that one can read the contents of STs, even after shrinking.

As an ST is created for self-learning, every command can be executed by the learner. The procedure to practise is simple: Listen to a command; pause the video; try it out on the software; if it works, proceed with the next command; if not, rewind the video and listen to the command once again. Repeat this until the whole ST is completed. As every command has to be repeated, our method promotes active learning.

13.3.2 Motivation for SELF Workshops

As STs are created for self-learning, it is possible to conduct workshops without domain experts. In this section, we describe SELF Workshops, the word SELF being an acronym of Spoken Tutorial based Education and Learning through free FOSS study. Although STs are available for download, there are many benefits in organised workshops:

1. If a college agrees to the idea of SELF workshops, it may organise them during class hours and allow their students to participate in them. Independent access to Internet may not be available to the students during college hours, otherwise.
2. Training is possible also to students who do not have their own laptops – the college infrastructure can be used for this purpose.
3. The conductor of the workshop at the college can interact with the ST team and ensure that all the systems in their computer lab are hardware and software ready before the start of a workshop.
4. If a college administration is convinced of the efficacy of SELF workshops, it can make this training mandatory on some topics, for example, C and Java for their curriculum or for placement.
5. Colleges provide a convenient environment to conduct online tests. Moreover, a college teacher can proctor the tests. We conduct online tests only under the proctoring mode.
6. When a college uses STs through SELF workshops or otherwise, there is an added authenticity and increased acceptance.

Internet is not required at the time of SELF workshops – it is required only at the time of online tests. Before conducting a SELF workshop, the conductor of the workshop gets all the required ST either by downloading from our website or through CDs from our team and copies them on each computer system for offline use. A similar method is applicable for the target software as well. Such a coordination helps facilitate the conduct of online tests as well. It is easy to scale up this activity: From the scrolling list of workshops on Spoken Tutorial Project, we expect to conduct about 10,000 SELF workshops in this year.

13.3.3 Instruction Sheet

A set of Spoken Tutorials has to be studied if one wants to learn a FOSS. For example, one needs 10 STs to learn LaTeX, 9 to learn Linux, 17 to learn C and so on. We use *instruction sheets* to convey this information.

An instruction sheet contains the following information: (1) It lists the tutorials to be studied for a particular FOSS and the sequence of study. (2) It gives additional instructions or tasks to be carried out. For example, it may state the following: *At 5:45 min, reproduce the calculations shown in the tutorial.* (3) It may give additional explanation of the following type, which may have been missed out in the video: *At 3:23 min, the author completes the explanation of how a source file is created. Its use will be explained now*. (4) It may clarify some ambiguities, for example, it may say the following: *Note that* `pdflatex` *is one command; there is no space between* `pdf` *and* `latex`. (5) Minor mistakes in the tutorial, which do not warrant a correction in the video can be addressed. Here is an example of it: *At 7:42 min, read as colon operator, although the ST says semicolon operator*.

We arrive at instruction sheets through pilot workshops (Moudgalya 2011b). One begins a pilot workshop with an initial draft of the instruction sheet, based on the initial vision of the ST creation team. The instruction sheet is updated based on the difficulties and the doubts the students have. The help feature for the `pdflatex` command explained above is based on the difficulty faced by the students, for example. The instruction sheet is improved until all possible difficulties associated with the target STs are sorted out. If major flaws are found, however, we recreate the STs.

The set of guidelines for the first video in an instruction sheet is usually elaborate as many doubts, including the obvious ones, have to be answered. The guidelines for subsequent tutorials need not be detailed and one may reduce them gradually or steeply, depending on the pilot workshops. A sample LaTeX instruction sheet is available at ST Team.

13.3.4 Duration of SELF Workshops

The SELF workshops are of 2-h duration. During this workshop, a student learns how to use an ST. They also practise three or four STs, each of which is of 10-min duration. If the students are interested, they can copy all the STs on to a storage device, such as a pen drive, and study at home. They may appear in an online test, which may be organised about 2 weeks after a SELF workshop is conducted.

One of the reasons for choosing a duration of 2 h for a SELF workshop is to reduce the organisational cost and to make the computer facility available to a larger number of students. For example, it may be possible to conduct a SELF workshop every evening or three workshops on holidays. As these workshops are conducted free of cost, it is important to cut down losses – reduce the time spent on uninterested students, who may have participated in the SELF workshops for various reasons. The organisers also need not give anything to eat or drink in 2-h workshops.

13.3.5 Conductor of SELF Workshops

SELF workshops are conducted by a volunteer, a student or a staff member of a college, referred to as a *conductor*. As the STs are created for self-learning and the instruction sheets further explain what to do, it is not required for a conductor to be a domain expert at all. The role of the conductor of a SELF workshop is to enforce discipline and to help convey the method of using STs.

We will illustrate the role of a conductor with the help of two examples. Many students who appear in a Linux workshop do not know the difference between a terminal and an editor. Some of them type a command on a terminal and wait for an answer. The conductor of the workshop should point out the mistake and ask the student to start the tutorial from scratch. In a Linux workshop, some commands are to be executed in the background with the help of ampersand (&) operator. The participants who forget to use & will complain that the subsequent commands do not work. The conductor should point out the mistake and ask the students to start the tutorial from scratch, once again.

The reason for asking the students to start from scratch in case of mistakes is that retrieving from a mistake could require domain expertise. The conductor, who is not necessarily a domain expert, may not be in a position to address this issue. Moreover, if the conductor starts addressing such issues, they will not be able to handle large numbers of students and the 2-h duration could become insufficient. Finally, the time a student has to spend extra in case of a repeat listening is about 5 min, which is not much. At the end of a SELF workshop, a student will realise that if they follow exactly what is shown in an ST, everything will work correctly.

Because of the generality of the suggested procedure, a conductor is in a position to conduct SELF workshops on other topics also, after successfully completing one. This is an important factor that has helped us scale up the number of SELF workshops.

13.3.6 Learning in a SELF Workshop

The SELF workshops are somewhat dictatorial in nature, with the learning outcome to match the contents of STs. Given that there is no support of domain experts in the SELF workshops, the students are expected to do only the things suggested in the STs. The students can, of course, try the things not covered in a tutorial. If they get stuck, the conductor may advise the students to close the current ST and to move on to the next one.

If we do not encourage students to try out things on their own, do they learn anything in a SELF workshop? It turns out that they learn quite a bit. For example, most students learn the following in a LaTeX SELF Workshop: (i) What is meant by compiling? (ii) How to write letters in LaTeX? (iii) How to write reports? (iv) How to write mathematical equations? (v) Introduction to presentation using Beamer (Moudgalya 2011b). To the best of our knowledge, though, no other method can a student learn so much in 2 h. In other words, for most students, what we propose for a workshop is new anyway and hence it makes no sense to try out something else that we do not cover and for which no help may be available. We have recently implemented an online forum to answer the questions a student may have in STs (Spoken Tutorial Project).

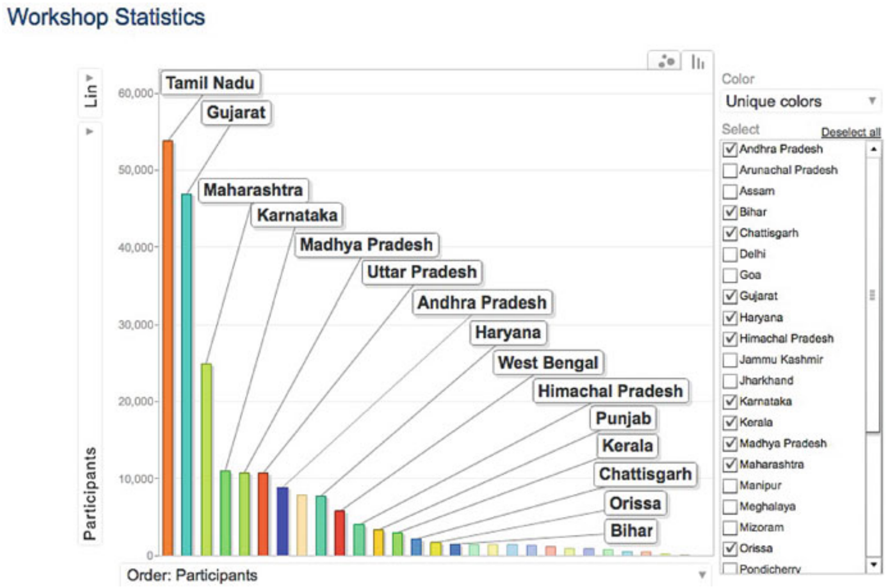

Fig. 13.2 Number of students who have undergone SELF workshops in different parts of India, as of 11 Feb. 2014

13.3.7 Other Support Services

In this section, we briefly discuss the web and online testing support. Every ST can be downloaded from our website free of cost and without any registration. In addition, we provide the following to support the users of ST: Outline, Script and Timed Script. In addition, all the files required to practise with an ST are provided. For example, along with the LaTeX Tables and Figures ST, we provide the following files: `tab-fig.tex`, `iitblogo.pdf`, `iitb.pdf` and `cclicesses.sty`. Similarly, for the C and C++ Function Call ST, we provide the files `callbyval.c` and `callbyref.c`.

About 215,000 college students have undergone SELF workshops until now. Figure 13.2 gives a statistics of the number of students who have undergone SELF workshops in different parts of India. We conduct online tests for students who have gone through ST and give certificates for those who score passing marks. More than 50,000 students have undergone online tests with about 75 % pass rate. We are in the process of implementing programming-type questions with a requirement that a student should get at least one working code to pass a test.

The pedagogical and the effectiveness aspects of our approach have been summarised in Eranki and Moudgalya (2012a,b,c, 2013a,b).

13.4 Testimonials and User Feedback

In this section, we present the user feedback received from about 25,000 of the participants of SELF workshops. We now collect feedback from only those participants who have access to the Internet. It is interesting to note that only about a fourth of all the SELF workshop participants undergo our online tests. Although some students undergo online tests through Internet browsing centres that can be hired for this purpose, it is an exception.

In Table 13.1, we show the number of boys and girls who gave their feedback on the basis of the state they are from and the FOSS topic of their SELF workshop. One can see that the respondents are from a wide geographical area and their inputs are on different FOSS topics.

The participants of SELF workshops, as distributed in Table 13.1, gave the following feedback. When asked about the quality of instructional material used in the SELF workshops, the response was as in Fig. 13.3. One can see that more than 80 % of the respondents thought that the quality was good or very good. When asked how good the college computer infrastructure was, we received the response as in Fig. 13.4. Only 60 % of the respondents felt that it was good or very good, with about 30 % of them feeling that it was just fair. This is of course expected as all sorts of colleges, including those that do not have a good infrastructure, have taken part in the SELF workshops. When asked how good the conductor of the workshop in their college was, we received the response as in Fig. 13.5. More than 80 % of the respondents feel that their workshop organiser was good or very good. As the same person can conduct workshops on many topics, the conductors become good quickly. When asked how they would rate the mentor from the Spoken Tutorial Team at IIT Bombay who came on the Skype and talked to them, the feedback was as in Fig. 13.6. Once again, 80 % feel that they are good or very good. When asked about the overall quality of the workshop, we received the feedback as in Fig. 13.7. When asked about their perception of the applicability of the FOSS system that they learnt, they gave the reply as in Fig. 13.8. Although about 75 % of the students think

Fig. 13.3 Feedback on the quality of instructional material

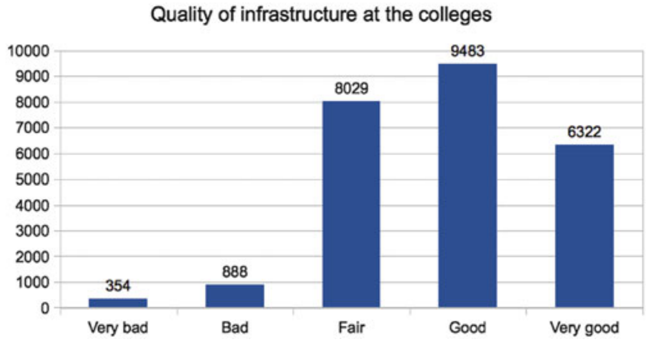

Fig. 13.4 Feedback on the quality of the computer infrastructure in the colleges

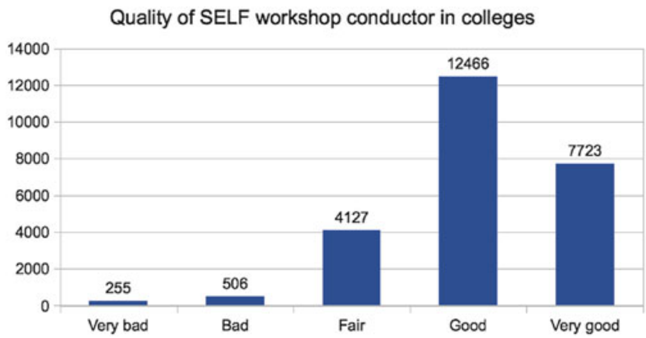

Fig. 13.5 Feedback on the quality of the conductors of the workshop in the colleges

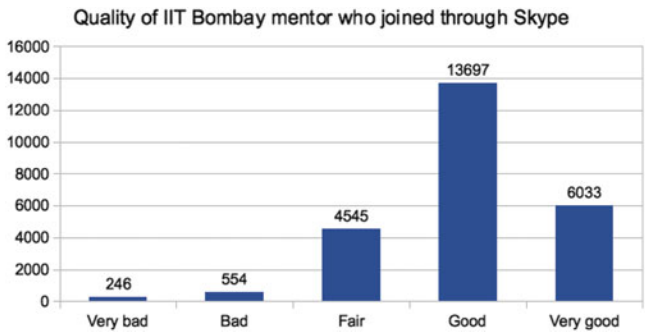

Fig. 13.6 Feedback on the quality of the mentor from the Spoken Tutorial Team at IIT Bombay who joined through Skype

Fig. 13.7 Feedback on the overall quality of the workshop

Fig. 13.8 Feedback on the applicability of what is learnt in SELF workshops

that the overall quality of the SELF workshop is good or very good, just a little over 50 % of the students only feel that what they learn is applicable quite a bit or a lot. This shows that curiosity also plays a role in participating in these workshops. Nevertheless, about 85 % of the people feel that they are likely to or quite likely to or definitely will recommend this methodology to others, as can be seen from Fig. 13.9.

It is no wonder that universities and government departments have started adopting the ST methodology in their curriculum. For example, Himachal Pradesh (HP) University has included the ST material under the Choice Based Credit System for its 77 affiliated colleges (HP University 2013). The B.Sc (IT) students of HP University have to do one three-credit course from the following four, with the instructional material being in the form of ST: (i) Basic IT-based skills (Linux, LibreOffice, Firefox and Tux typing), (ii) Blender, (iii) GIMP and (iv) Java. The B.Sc (CS) students of HP University have to do one three-credit course from one of the following four, using the ST instructional material: (a) Python, (b) Scilab, (c) C and C++ and (d) PHP and MySQL. The Tamil Nadu Department of Technical Education is in the process of introducing the ST methodology to all the about 450 polytechnic colleges in the state (Tamil Nadu Dept. of Technical Education 2013).

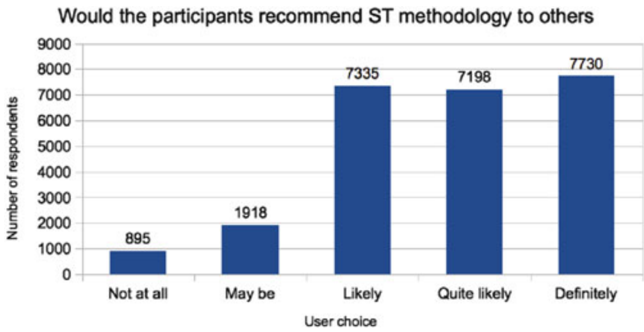

Fig. 13.9 Feedback on whether they will recommend the ST and the SELF workshop methodology to others

13.5 Conclusions and Future Work

The ST project, which began as a documentation effort for FOSS, has turned out to be a full-blown training programme. We have received a large number of testimonials from students and teachers that claim that the ST methodology helps (i) self-learn IT topics, (ii) improve job opportunities, (iii) learn FOSS tools better than their commercial counterpart and (iv) reach even those who are weak in English without affecting the employment potential in the IT sector.

We are now working with officials who coordinate universities, engineering colleges, polytechnic colleges, schools and citizen centres to spread the IT literacy. To this end, our team takes care of the following activities: (a) mapping the academic content, (b) creating study material, (c) providing access to online tests and (d) training the instructors.

Using ST, more than 100,000 students are trained in a year through the SELF workshop mechanism in one FOSS or another. The number of page views of our portal (Spoken Tutorial Project) has been doubling every year. We expect about three million page views in the current year, with the average time spent being about 8–9 min (Awstats). We have received positive feedback from more than 25,000 users about the efficacy of the ST methodology. We are receiving a large number of testimonials from the satisfied students and teachers (Spoken Tutorial Team) about the different benefits that they have received through the ST methodology.

We are in the process of building forum-based support to answer student questions (Spoken Tutorial Project). We have enabled discussions on the basis of the timeline of a tutorial. Although this will make it difficult to replace a tutorial, we believe that this is the most friendly way for students to self-learn and get individualised help through ST. Hopefully, this will also help us address the substantial changes when a new version of the software is released.

We are now working on methods to ensure that the users of STs learn properly so that most of them can pass our online tests. Correlating the learning and the actual benefit is also on our radar. Finally, *bridging the digital divide* is one of the ultimate goals of this project, although not much has been achieved so far.

The National Mission on Education through ICT (Ministry of Human Resource Development) which funds the ST effort also funds the world's lowest-cost access device, Aakash (Moudgalya et al. 2013). Given that it can be used as a full-blown computer system (Patil and Patnaik 2013) and that a lot of applications are already ported (Aakash Team), Aakash can be used to spread IT literacy. Without such an inexpensive but a powerful access device, making IT literacy available to every Indian would be next to impossible.

Acknowledgements The author wants to thank Nancy Varkey and Shyama Iyer for leading the efforts in the creation and the use of ST, respectively. He thanks Vishnu and Sanmugam for the web support and in collating the user feedback. He thanks Kiran Eranki for carrying out many useful research studies on the use of ST. The author wants to thank the entire FOSSEE (http://fossee.in) team for supporting the ST efforts. Finally, he thanks the funding agency, National Mission on Education through ICT (Ministry of Human Resource Development), for a generous financial grant.

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