Ubiquitous and Mobile Learning in the Digital Age

Demetrios G. Sampson • Pedro Isaias
Dirk Ifenthaler • J. Michael Spector
Editors

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Editors
Demetrios G. Sampson
Department of Digital Systems
University of Piraeus
Piraeus, Greece

Pedro Isaias
Universidade Aberta
Lisboa, Portugal

Dirk Ifenthaler
Department of Educational Science
University of Freiburg
Freiburg, BW, Germany

J. Michael Spector
Department of Learning Technologies
University of North Texas
Denton, TX, USA

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Preface

This edited volume contains selected expanded papers from the Cognition and Exploratory Learning in the Digital Age (CELDA) 2011 conference (http://www.iadis.org/celda2011/), together with invited chapters on emerging research issues. It addresses the current developments concerned with context-aware adaptive and personalized learning systems, mobile and ubiquitous learning environments and social web technologies, as well as virtual worlds and game-based learning for informal and formal educational settings. These developments have created both opportunities and areas of concern. Hence, this edited volume aims to cover both technological and pedagogical issues related to these developments.

We organized the chapters included in this volume around four themes: (a) context-aware adaptive and personalized systems for formal and informal learning; (b) mobile and ubiquitous informal and formal learning environments; (c) social web technologies for new knowledge representation, retrieval, creation, and sharing in informal and formal educational settings; and (d) virtual worlds and game-based informal and formal learning.

In Part I, context-aware adaptive and personalized systems for formal and informal learning, several issues are described and discussed. In the first chapter, the authors address the increased interest on context-aware adaptive and personalized mobile learning systems that aim to provide learning experiences delivered via mobile devices tailored to the educational needs, the personal characteristics, and the particular circumstances of the individual learner or a group of interconnected learners. Their chapter is an introduction to the field of context-aware adaptive and personalized mobile learning systems (Demetrios G. Sampson & Panagiotis Zervas, Chap. 1). The next chapter discusses the increased use of cloud computing in education. The pros and cons of the use of current cloud services in education are presented, with a focus on privacy and security issues. The US context is studied, concluding with suggestions for safe and sensible use of cloud computing in education (Alan S. Weber, Chap. 2). Next, a context-aware mobile content adaptation mechanism and a corresponding process based on a notation language (namely, IMS Learning Design specification) are presented, along with design requirements for tools that enable authoring and delivering of context-aware learning designs with mobile content adaptation features (Panagiotis Zervas, Demetrios G. Sampson, Sergio Eduardo Gómez Ardila, & Ramón Fabregat, Chap. 3). Lastly, a student-centered multi-agent system with adaptive features for virtual courses design and construction is proposed (Demetrio A. Ovalle, Francisco J. Arias, & Julian Moreno, Chap. 4).

In Part II, chapters focus on mobile and ubiquitous informal and formal learning environments. At the first chapter of this part, the authors present a mobile learning platform, which provides opportunities to students to diversify learning according to their own needs by using text, audio, and video educational materials (Elissaveta Gourova, Asya Asenova, & Pavlin Dulev, Chap. 5). Next chapter describes two case studies based on activity theory, with the use of cell phones in Calculus I classes, and analyzes the data collected (Silvia Cristina Batista, Patricia Alejandra Behar, & Liliana Passerino, Chap. 6). The following chapter is about mARble®, an augmented reality mobile learning environment, which is used in a medicine course (Urs-Vito Albrecht, Marianne Behrends, Herbert K. Matthies, & Ute Von Jan, Chap. 7). The last chapter of this part explores location-based environments for learning by addressing the technological, pedagogical, and educational issues in location-based context-aware mobile learning. The chapter demonstrates that context-aware mobile learning is an effective approach in implementing location-based environments for learning, bringing great opportunities for ubiquitous learning in the digital age (Qing Tan, Tzu-Chien Liu, & Martha Burkle, Chap. 8).

In Part III, chapters address social web technologies for new knowledge representation, retrieval, creation, and sharing in informal and formal educational settings. In the first chapter of this part, authors present a set of teaching strategies, tasks, and practices for the development of cross-curricular competences in engineering through web 2.0 social objects (Mercedes Rico, Julian Coppens, Paula Ferreira, Héctor Sánchez, & J. Enrique Agudo, Chap. 9). The next chapter presents Presence Plus, a model for identifying social presence in educational forums and chats. The chapter concludes with a brief description of the software developed to process text cues as an aiding tool for tutors as well as results from a manual and automatic analysis of corpus used in the study (Hélvia Pereira Pinto Bastos, Júlia Kikuye Kambara da Silva, Magda Bercht, & Leandro Krug Wives, Chap. 10). In the final chapter of this part, the author uses MediaWiki for exploring the data logs generated by wikis as students performed collaborative writing activities and written comments posted by students on the discussion page of the wiki (Said Hadjerrouit, Chap. 11).

In Part IV, the chapters focus on virtual worlds and game-based informal and formal learning. At the first chapter of this part, the authors present an educational system referred to as Cyber Assistant Professor 2 (CAP2), which is an interactive e-education system based on the three-dimensional computer graphics (3D-CG) animation and voice synthesis. The chapter reports results about the effectiveness of the presented system (Hiroshi Matsuda & Yoshiaki Shindo, Chap. 12). Next chapter presents a case study of experiential learning in healthcare simulation. The case study focuses on measuring learners' experiences from educational medical simulations (MedSims) with regard to three dimensions: functional skills, attitudes toward usefulness of MedSims in professional education, and career intentions (Pamela Leonard, Elena Libin, Yuri Millo, & Alexander Libin, Chap. 13). In the next chapter, the authors discuss ideas related with using tangible programming as a motivating activity for computer science. The results of their survey highlight the difficulty both of measuring (and understanding) students' attitudes toward programming and the continuing need for innovative research and design in responding to this issue (Yingdan Huang, Jane Meyers, Wendy DuBow, Zhen Wu, & Michael Eisenberg, Chap. 14). The next chapter presents an example of a recent study on a game-based platform for English teaching and learning and discusses the role of game-based learning in primary school viewed from the perspective of educational policy. The authors focus mainly on data which have been produced in connection with a research project, and they approach the issue of policies through three case studies of educational policy in Denmark, Portugal, and Vietnam (Bente Meyer, Birgitte Holm Sørensen, & Lars Birch Andreasen, Chap. 15). In the last chapter of this part, the authors present a serious game environment to support organizational changes in industry by helping to understand product lifecycle management (PLM) (Thibault Carron, Philippe Pernelle, & Jean-Charles Marty, Chap. 16).

Part V presents an epilogue, which provides a discussion of issues associated with research and development to effect a more productive connection between technology and the design and deployment of assessments that can *measure what matters* and support learning in a digital world. The chapter focuses on presenting a cognitive model of multisource comprehension and on using that model to design and deploy technology-based assessments of components of multisource comprehension (James W. Pellegrino, Chap. 17).

This is the fourth edited volume resulting from a CELDA conference. We are convinced that this work covers the current state of research, methodology, assessment, and technology. When we have so many outstanding papers as were presented in Freiburg, Germany, 2008; Rome, Italy, 2009; Timisoara, Romania, 2010; and Rio de Janeiro, Brazil, 2011, we will certainly seek to also have future edited volumes, as this benefits the entire professional and research community.

Piraeus, Greece — Demetrios G. Sampson
Lisbon, Portugal — Pedro Isaias
Freiburg, BW, Germany — Dirk Ifenthaler
Denton, TX, USA — J. Michael Spector

About the Authors

J. Enrique Agudo, from Zafra in south western Spain, is an engineering specialist in Hypermedia applied to educational contexts. He holds a Ph.D. in Computer Science from the University of Extremadura. At present, he works as a full-time assistant lecturer in the Telecom and Information Systems Technology department of the same academic institution. His most recent research involves work on educational ICT applications, adaptive hypermedia systems, e-learning, technology-enhanced learning, and computer-assisted language learning. He is an active participant in various projects on competence-based learning, mobile learning for young children, and ubiquitous learning.

Urs-Vito Albrecht studied medicine at the Hannover Medical School and graduated 2002. In 2004 he received his doctoral degree. After completing his studies, his professional career included clinical research and management positions, e.g., at the Sobell Department of Motor Neuroscience and Movement Disorders, Institute of Neurology, University College London, at the Epidemiological Cancer Registry of Lower Saxony, as well as at the Institute of Legal Medicine at the Hannover Medical School. He received a master's degree in Public Health in 2011. Currently, he is a leader of the MedAppLab research group of the Peter L. Reichertz Institute of Medical Informatics at the Hannover Medical School. This group researches the ethical, legal, and pragmatical aspects of using mobile devices and the accompanying applications in the medical field. He is a designer of mobile applications like the prize-winning mobile Augmented reality blended learning environment mARble®. In addition, he is a lecturer in legal medicine and medical informatics and secretary of the Ethics Committee at the Hannover Medical School.

Lars Birch Andreasen is an associate professor at the Department of Learning and Philosophy, Aalborg University, Copenhagen. His research interests are dialogic communication, collaboration in virtual learning environments, information literacy, and lifelong learning.

Francisco Javier Arias is a research engineer at *Universidad Nacional de Colombia, campus Medellin*. He is presently a member of GIDIA (Artificial Intelligence Research & Development Group). He has published over 20 refereed publications in Journals, Books, and International Conferences. He received his Engineering and master's degree in Computer Science at National University of Colombia in 2007 and 2010, respectively. His research interests are in the areas of Distributed Artificial Intelligence and Multi-Agent Systems (MAS), Neuro-Fuzzy Systems, and Simulation Systems.

Asya Asenova is an assistant professor at the Department of Biology Education, Faculty of Biology of Sofia University. She is a member of the University Center for eLearning and ESERA member, and leads a practice in bachelor and master degree: Scientific method in biology education, Pedagogical practice to Didactics in education of biology, Informational technology in education, and Development of educational resources, tools, and electronic-based courses for students in relevant disciplines (Audiovisual and information technology in teaching and educational management basics). Her main research field comprises e-learning, environmental education and environmental protection, electronic media for training, and applied psychology.

Hélvia Pereira Pinto Bastos holds a Ph.D. degree in Computers in Education from the Universidade Federal do Rio Grande do Sul (UFRGS). She teaches English for Specific Purposes at the Instituto Federal Fluminense. Her major interests are Web-Based Language Learning, Discourse Analysis, and Computer Mediated Communication.

Silvia Cristina Freitas Batista was born in Campos dos Goytacazes, Rio de Janeiro, Brazil. In 1987, Batista has graduated in Science—Specialization in Mathematics—from the Faculdade de Filosofia de Campos. She received her master's degree in Engineering Sciences, focus on Production Engineering, in 2004, from the Universidade Estadual do Norte Fluminense Darcy Ribeiro, Rio de Janeiro. She received her Ph.D. in Information Technology in Education from the Universidade Federal do Rio Grande do Sul Federal—UFRGS in 2012. Batista is a professor at Instituto Federal Fluminense, Brazil.

Patricia Alejandra Behar was born in Buenos Aires, Argentina. She has graduated in the computing (1986–1990) from the Pontifícia Universidade Católica do Rio Grande do Sul, PUCRS, Brazil. She received her master's degree, in 1993, and Ph.D., in 1998, in Computer Science from the Universidade Federal do Rio Grande do Sul (UFRGS), Brazil. She is professor at the Education College and at the Post Graduation Programs in Education and Information Technology in Education at the Universidade Federal do Rio Grande do Sul (UFRGS).

Marianne Behrends studied German literature, history, and social psychology at the University of Hannover and received her M.A. in 1993. After finishing her studies, she worked for several publishing companies, covering areas from project management to didactical conception and realization of digital learning material. She also served as a freelance lecturer. Since 2001, she has been a member of the Institute of Medical Informatics at the Hannover Medical School. In 2007, the Hannover Medical School awarded her the doctoral degree (Dr. rer. biol. hum.) for her research on factors for success and satisfaction in different learning situations. Currently Dr. Marianne Behrends is a researcher in the Peter L. Reichertz Institute for Medical Informatics, working on e-learning related projects.

Magda Bercht is an associate professor at UFRGS. She has a doctoral degree in Computer Science from UFRGS, and her research activities are related to affective computing, artificial intelligence, and computers and education.

Martha Burkle is a research associate for the NSERC/iCORE Project on Adaptivity and Personalization in Informatics Project, University of Athabasca. Her work has been dedicated to advancing research on the implementation of information and communication technologies to innovate teaching and learning for development. Her main research interests lie in the area of the impact of technologies for the innovation of learning, the use of virtual environments for teaching and learning, learning pedagogies, and the influence of technologies in cognitive abilities. She has been involved in a number of research projects for e-learning exploration in development contexts, testing the impact of mobile technologies in just in time training, the use of virtual environments to facilitate hands-on learning, and the use of technologies for development. Dr. Burkle is the associate editor for the Canadian Journal of Learning Technologies (CJLT). She held CISCO's Chair in e-learning from 2006 to 2012. Dr. Burkle received her Ph.D. in Technology Policies and Higher Education in 2003 from Sussex University in the UK. She has organized and chaired international conferences and workshops in the area of technology policies for development, including the World Summit on the Information Society in Geneva, 2003.

Thibault Carron is an associate professor of Computer Science at the University of Savoie. He is a member of the LIP6 laboratory (Paris). He obtained his Ph.D. in Computer Science at the "Ecole Nationale Supérieure des Mines de Saint-Etienne" in 2001. His current research interests deal with collaborative activity observation and with learning games. He is a member of the scientific committee of the European Conference on GBL. He is also involved in several projects in this field.

Julian Coppens is an assistant lecturer in the Department of English Philology at the Universidad de Extremadura in Spain. Apart from delivering English as a Second Language subject to undergraduate students on degree programs in Spain, he works as a teacher trainer for the Government of Extremadura.

Júlia Kikuye Kambara da Silva has a bachelor's degree in Computer Science from UFRGS and currently is attending a master's degree in the Post-Graduation in Computer Science Program (PPGC) at UFRGS. Her research activities are related to text mining.

Wendy DuBow is a research scientist at the National Center for Women & Information Technology (NCWIT). She has substantial experience in planning and implementing both short-term and multi-year research projects and performing mixed method, quantitative, and qualitative studies, including public opinion surveys, needs assessments, and program evaluations. She has trained clients and peers in qualitative data gathering and analysis and provided technical assistance in research methods to nonprofit organizations, youth-serving programs, and governmental organizations. As an active member of the Colorado Evaluators' Network as well as the American Evaluation Association (AEA), DuBow regularly presents on effective evaluation methods, especially for increasing the cultural sensitivity of evaluations. At NCWIT, she conducts both program evaluation and social science research concerning the recruitment and retention of girls and women in computing. Her work in recent years has convinced her that if she had known about computer science when she was younger, she probably would have been a CS major because of the powerful problem-solving capabilities a computing degree bestows.

Pavlin Dulev is a Ph.D. student at the Department Information Technology of Sofia University, Faculty of Mathematics and Informatics. His research topic is focused on m-learning. His further research interest and professional expertise comprise telecommunications and mobile technologies. Presently, he is occupied as Instructor, Observer, and Curriculum Leader in Local BANT Cisco Academy.

Michael Eisenberg received his Ph.D. from the Massachusetts Institute of Technology in 1991. He is a professor of Computer Science, and a member of the Institute of Cognitive Science, at the University of Colorado, Boulder, where he has been teaching since 1992. He and his wife Ann together direct the Craft Technology Lab at CU Boulder; the research interests of the Lab focus on mathematics and science education, blending the most educationally powerful features of new technologies with traditional children's crafts.

Ramón Fabregat is an associate professor at the Department of Architecture and Computer Science of the Universitat de Girona. He is a computer engineer of the Universitat Autonoma of Barcelona (UAB), Spain. He received a Ph.D. in Industrial Engineering from the Universitat de Girona, Spain, in 1999. He is codirector of the Broadband Communications and Distributed Systems research group and member of the Institute of Informatics and Applications at the University of Girona, Spain. He is the coauthor of the book "Multi-Objective Optimization in Computer Networks" (CRC Press, 2007) and author of more than 150 publications in international journals and conferences. He conducts active research in various information technology related areas including adaptive hypermedia systems, user modeling, e-learning systems, and augmented reality systems. He has been main researcher of projects such as ADAPTAPlan, A2UN@, ALTER-NATIVA, and ARelLS among others.

Paula Ferreira is an associate professor of English for Specific Purposes at the University of Extremadura (Spain) and a Ph.D. candidate. Her research focuses on computer-assisted language learning (CALL), new technologies, and virtual environments. She is a member of the Grupo Extremeño de Computer-Assisted Language Learning (GExCALL) research group.

Sergio Gómez is currently doing a Ph.D. in Computer Science at the Universitat de Girona, Spain. He received an M.Sc. in Computer Science from the Universitat de Girona in 2008. He is doing an active research in technology-enhanced learning and related areas including mobile learning, context-aware computing, and adaptive hypermedia systems. He has worked in the implementation of m-learning and e-learning, design and collaborative authoring and execution tools, and the design of learning objects both supported on ICT and standards.

Elissaveta Gourova is an associate professor at the Department of Software Engineering at the Faculty of Mathematics and Informatics of Sofia University. She works since 2006 as a guest lecturer at New Bulgarian University and Technical University-Sofia. She has professional experience as Head of department at the Ministry of Transport and Communications, research fellow at DG JRC-IPTS, member of expert groups of the Council of Europe, EUTELSAT, and the of Information Society Forum at the European Commission. Presently, she is National Contact Point for FP7 program People, and EURAXESS National coordinator. Her primary research is cross-disciplinary focused on Knowledge management and open innovation. Her research interests further focus on e-skills, distance learning, mobility, and career of researchers.

Said Hadjerrouit is currently a professor of Computer Science at the Faculty of Technology and Science, University of Agder, Kristiansand (Norway). He received M.S. and Ph.D. degrees in software engineering and artificial intelligence from the Technical University of Berlin (Germany) in 1985 and 1992, respectively. He joined the University of Agder in 1991. He has extensive experience in teaching object-oriented programming, Web engineering, software development, databases, didactics of informatics, ICT in mathematics education, and ICT-based learning. His research interests include object-oriented software development, software engineering education, didactics of informatics, ICT in mathematics education, e-learning, technology-enhanced learning, Web-based learning, Web 2.0 technologies, and social software.

Birgitte Holm Sørensen is a professor at the Department of Learning and Philosophy, Aalborg University, Copenhagen, and leader of the Research lab in ICT and Educational Design (ILD). Her research interests are ICT and learning, children and young people in and outside school. She has been leader of several national and international research projects.

Yingdan Huang is a Ph.D. candidate in the Department of Computer Science, University of Colorado at Boulder. Before attending CU Boulder, she obtained a Master of Science in Computational Design from Carnegie Mellon University and a Bachelor of Engineering degree in Architecture from Beijing University of Technology. Exploring both architectural design and computational worlds, Yingdan has been dedicated to integrating art, design, and computation. Her Ph.D. research focuses on the development and realization of *Easigami*—a configurable folded-sheet tangible innovative 3D user interface.

Dirk Ifenthaler research interests focus on the learning-dependent progression of mental models, complex problem solving, decision making, situational awareness, and emotions. He developed automated and computer-based methodologies for the assessment and analysis of graphical and natural language representations (SMD Technology, HIMATT, AKOVIA). Additionally, he developed components of course management software and an educational simulation games (DIVOSA, SEsim). He is also interested in the development of educational software and learning management systems (LMS) as well as technology integration into the classroom. Dr. Ifenthaler has published multiple books and book chapters as well as numerous articles in leading journals of the field.

Pedro Isaias is a professor at the Universidade Aberta (Portuguese Open University) in Lisbon, Portugal, responsible for several courses and director of the master degree program in Electronic Commerce and Internet since its start in 2003. He is cofounder and president of IADIS—International Association for Development of the Information Society, a scientific nonprofit association. He holds a Ph.D. in Information Management (in the specialty of information and decision systems) from the New University of Lisbon. As author of several books, papers, and research reports, all in the information systems area, he has headed several conferences and workshops within the mentioned area. He has also been responsible for the scientific coordination of several EU-funded projects. He is also a member of the editorial board of several journals and a program committee member of several conferences and workshops. At the moment he conducts research activity related to information systems in general, e-learning, e-commerce, and WWW related areas.

Ute von Jan is a researcher at the Peter L. Reichertz Institute for Medical Informatics, located at the Hannover Medical School. In 1997, she received her degree in Computer Science with an emphasis on medical informatics from the University of Hildesheim, and in 2007, the Hannover Medical School awarded her the doctoral degree (Dr. rer. biol. hum.) for her thesis dealing with ultrasound volume segmentation and visualization techniques in orthopedics. Her current interests include not only medical image processing and visualization but also research regarding the use of mobile applications in medicine and medical education.

Pamela Leonard focuses on project management, consultation, and support for regional patient safety/risk management initiatives. She leads clinical quality improvement activities that address patient safety initiatives and system improvement activities in partnership with operations and medical group. She facilitates the application of human factors, high reliability, and continuous performance improvement principles and strategies. She provides expertise to organize and implement simulation-based education for frontline healthcare teams. Resource throughout the Region for issues related to Patient Safety and Risk Management.

Alexander Libin is a scientific director at the SiTEL and MHRI of MedStar Health. He leads the research efforts of interdisciplinary teams working across health care, medical training and education, and cybertechnology. Dr. Libin works as a PI and a Co-PI on various clinical, educational, and multimedia projects funded by the NIDDR at the ED, TATRC at the DOD, Navy Office of Research, as well as participating in the nationwide collaborative efforts such as GHUCCTS at the Georgetown-Howard Universities. Dr. Libin is a published researcher who is proficient in both quantitative and qualitative methodology. More than 50 papers and 11 books in four languages (Russian, English, Spanish, and Japanese) on a wide range of topics in multimedia technology and cyberpsychology, public health and health literacy, disability and rehabilitation have appeared in national and international journals. His work in Robotherapy and Robotic Psychology, together with Dr. Elena Libin, resulted in his being acclaimed as an outstanding contributor to the assistive technology field and resulted in two chapters for the *Encyclopedia of Applied Psychology* (Oxford, 2005).

Elena Libin is a Research Faculty at the Department of Psychology at the Georgetown University (Washington, DC), and the founder and director of the Institute of Robotic Psychology and Robotherapy™ at the Cyber-Anthropology™ Research, Inc., in Chevy Chase, MD (USA). Elena designed a unified methodology for studying coping and defense strategies people use in difficult and stressful life situations. Main published results include books *Coping Intelligence* (2008), *Psychology of Coping with Life Crises and Difficult Situations* (3rd edition, 2004), and *Phenomenology of Everyday Psychology* (2nd edition, 2004). Working for more than 15 years as individual and group counselor, psychotherapist, and educator, she created an original concept of Psychological Culture focused on nonclinical management of psychological problems. Since 2001 together with Dr. Alexander Libin she develops an innovative concept of Robotic Psychology and Robotherapy™, which emphasizes human-centered aspects of person–robot communication. Recent initiative of Drs. Elena and Alex Libin deals with the new field of Cyber-Anthropology that applies humanistic principles to the inevitable merge of artificial and human worlds.

Tzu-Chien Liu is the director and professor of the Graduate Institute of Learning & Instruction, National Central University. His research interests mainly focus on mobile learning and ubiquitous learning, instruction and learning sciences, the cognitive base of technology application, and innovative technology for education, interactive learning, and assessment. He has (co-)authored more than 140 book chapters and refereed journal and international conference papers. Dr. Liu is the associate editor of the Journal of Research in Education Sciences (Scopus index) and guest editor of the International Journal of Engineering Education Special issue (SCI index). He is also the associated editor Asia of the International Journal of Interactive Mobile Technologies (EBSCO index) and the editorial advisory board member of Educational Technology & Society (SSCI index). Dr. Liu served as invited reviewers for various eminent international journals including Educational Technology & Society, Journal of Computer Assisted Learning, Computers & Education and British Journal of Educational Technology. He has participated in more than 15 international conferences as a cochair or program committee member. Dr. Liu has received several research awards, such as "NCU Outstanding Research Award" in 2006, 2008–2011; besides, he was also awarded the "NCU Outstanding Teacher Award" in 2010.

Jean-Charles Marty is an associate professor at the LIRIS laboratory (Lyon, France). He was responsible for the "Traces and Observation" group at the SysCom laboratory (Université de Savoie) during 6 years. His research interests are in the observation of collaborative activities, through the traces of these activities. The results of his research are applied to Technology-Enhanced Learning, and particularly to Game-Based Learning Environments. Jean-Charles Marty participates in several projects in this field (Learning Adventure, Learning Games Factory, Serious Lab for Innovation, Pegase). He has organized an International School on Game-Based Learning in France in June 2011 (gbl2011.univ-savoie.fr).

Hiroshi Matsuda is currently an assistant professor of Department of Computer and Information Engineering at the Nippon Institute of Technology, Japan. He has a Ph.D. in Engineering. His research interests include 3D-Computer Graphics (3D-CG) animation and virtual reality. He has published over 30 research papers in authoritative journals, international conferences, and books for the past 5 years.

Herbert K. Matthies studied at the Otto-von-Guericke University in Magdeburg, where he received his diploma in mathematics in 1971. In 1976, he earned his doctor's degree. His professional career includes various research positions, e.g., at the Institute of Pharmacology and Toxicology at the former Medical Academy in Magdeburg (now part of the Otto-von-Guericke University), but also positions as a project leader at IBM. He started working at the Hannover Medical School in 1991, where he was instated as associate professor for Medical Informatics in 1998, became provisional head of the Institute of Medical Informatics in 2000, and became deputy director of the Peter L. Reichertz Institute for Medical Informatics of the Technical University of Braunschweig and the Hannover Medical School after the Medical Informatics departments of both universities had been merged in 2008.

Bente Meyer is an associate professor at the Department of Learning and Philosophy, Aalborg University. Her research interests are second and foreign language education, intercultural and citizenship education, as well as computer-assisted language learning (CALL). She has edited several books on media, ICT, and Learning.

Jane Meyers was a 5th year Ph.D. student working in the Craft Technology Group at the University of Colorado before joining a local company as an interaction designer. Her research interests include educational technology, the blending of interactive technologies and crafts, and researching methods for sharing and exploring tangible creations using Web 2.0 networks for tinkerers of every age.

Yuri Millo is the director of The Simulation and Training Environment Lab (SiTEL), part of MedStar Health in Washington, DC. Dr. Millo's main focus is education and training for healthcare force using innovative technologies and pedagogical approach for adult learners; as such he developed serious games focused on improving patient safety and quality of care, motion capture tools for surgical skill trainers on Xbox console, procedure simulators, and shell games for online and mobile healthcare education. At SiTEL he oversees the development of SiTELMS, the Learning and Content management system in use in several hundreds of hospitals nationwide, and the clinical Simulation Centers of SiTEL. Dr Millo is an active member in several organizations that promote simulation training including the American College of Surgeons, AIMS, and SSIH. He served in the Israeli Air Force as Rescue Team Commander, educating new team members in CTLS and combat techniques and developing CBT to simulate military field medical procedures. Dr. Millo graduated from Caregi Faculty of Medicine, Florence, Italy. He did his residency in general and vascular surgery in Tel Aviv and plastic surgery in Jerusalem, Israel. He completed a fellowship in pediatric plastic surgery in Vancouver, BC, Canada.

Julian Moreno is an assistant professor at *Universidad Nacional de Colombia, campus Medellin*. He is presently head of GUIAME (Educational Informatics Research Group). He has published over 30 refereed publications in Journals, Books, and International Conferences. He received his master's degree in Computer Science at National University of Colombia in 2007. He is currently a doctoral student in the Computer Science Program at the same university and also a doctoral student in the Educational Informatics Program at Federal University Rio Grande do Sul from Brazil. His research interests are in the areas of Distributed Artificial Intelligence, Virtual Learning Environments, and Intelligent Tutoring Systems.

Demetrio Arturo Ovalle is tenured professor at *Universidad Nacional de Colombia, campus Medellin*. He was head of the Department of Computer Science at School of Mines in the National University of Colombia, branch Medellin (2006–2008). He is presently head of GIDIA (Artificial Intelligence Research & Development Group), categorized as A1, maximum category established by Colombian National Science & Technology Bureau. He has published over 150 refereed publications in Journals, Books, and International Conferences. He received his master's and Ph.D. degrees in Informatics, respectively, from *Institut National Polythechnique* in 1987, and *Université Jospeh Fourier* in 1991, in Grenoble, France. His research interests are in the areas of Distributed Artificial Intelligence and Multi-Agent Systems (MAS), Virtual Learning Environments, Intelligent Tutoring Systems, Mobile & Ubiquitous Computing, Ambient Intelligence, Autonomic Systems, and Wireless Sensor Network.

Liliana Maria Passerino was born in Rosario, Argentina, where she graduated as Systems Analyst University, in 1987, from Universidad Tecnológica Nacional (UNR) Facultad Regional de Rosario (FRR). She received her master's degree, in 1992, in Computer Science from Universidade Federal do Rio Grande do Sul (UFRGS), and later, a Ph.D. Program of Computing in Education from the same university (UFRGS). She is professor at the Education College and at the Post Graduation Programs in Education and Information Technology in Education at the Universidade Federal do Rio Grande do Sul (UFRGS).

James W. Pellegrino is Liberal Arts and Sciences Distinguished Professor and Distinguished Professor of Education at the University of Illinois at Chicago. He also serves as codirector of UIC's interdisciplinary Learning Sciences Research Institute. His research and development interests focus on children's and adult's thinking and learning and the implications of cognitive research and theory for assessment and instructional practice. He has published over 270 books, chapters, and articles in the areas of cognition, instruction, and assessment. His current research is funded by the National Science Foundation and the Institute of Education Sciences. He has served as head of several National Academy of Sciences study committees, including cochair of the Committee on *Learning Research and Educational Practice*, and cochair of the Committee on the *Foundations of Assessment* which issued the report *Knowing What Students Know: The Science and Design of Educational Assessment.* Most recently he served as a member of the Committee on *Science Learning: Games, Simulations and Education* and as chair of the Committee on *Defining Deeper Learning and 21st Century Skills.* He is a past member of the Board on Testing and Assessment of the National Research Council and a lifetime member of the National Academy of Education.

Philippe Pernelle is an associate professor at the DISP laboratory (Lyon, France). He is responsible for the "AIP-Primeca" pole. His research interests are in the Product Lifecycle Management (PLM), in small and medium enterprises (SME). The results of his research are also applied to Technology-Enhanced Learning and particularly to Game-Based Learning Environments.

Mercedes Rico is an associate professor at the English Department of the University of Extremadura where she teaches English for Information Technology and Design for more than 18 years. Coordinator of the GexCALL research group, she is involved in postdoctoral research related to foreign languages, technology, and multimodal discourse.

Demetrios G. Sampson holds a Diploma in Electrical Engineering from the Democritus University of Thrace, Greece (1989) and a Ph.D. in Electronic Systems Engineering from the University of Essex, UK (1995). Currently, he is an associate professor at the Department of Digital Systems, University of Piraeus, Greece, senior researcher at the Centre of Research and Technology Hellas (CERTH), and an adjunct professor at the Faculty of Science and Technology, Athabasca University, Canada. He is the founder and director of the *Advanced Digital Systems and Services for Education and Learning* (ASK) since 1999. His main research interests are in the areas of Technology-Enhanced Learning. He is the coauthor of more than 272 publications in scientific books, journals, and conferences with at least 1,190 known citations (h-index: 20). He has received six times Best Paper Award in International Conferences on Advanced Learning Technologies. He is a Senior Member of IEEE and he was the elected Chair of the IEEE Computer Society Technical Committee on Learning Technologies (2008–2011). He is Co-Editor-in-Chief of the Educational Technology and Society Journal and a Member of the Steering Committee of the IEEE Transactions on Learning Technologies. He has been a General Chair in 13 International Conferences and a Program Committee Chair in 15 International Conferences, as well as a Keynote/Invited Speaker in 20 International Conferences and 18 National Conferences.

Héctor Sánchez joined the Universitary Center of Merida, University of Extremadura in 2002. He is currently an assistant professor of Computer and Telematic Systems Engineering Department at University of Extremadura. He received his Ph.D. in Computer Science at University of the Basque Country in 2002. His main research thrust is computer-based education. His research interests include computer-based educational games, adaptive hypermedia systems, elearning platforms, virtual environments and ubiquitous/multi-device educational systems.

Yoshiaki Shindo is currently a professor of Department of Computer and Information Engineering at the Nippon Institute of Technology, Japan. He also is a professor of Graduate School of Computer and Information Major at the same university. He has a Ph.D. in Computer Science. His research interests include 3D-Computer Graphics (3D-CG) animation and virtual reality. His latest development works include the Cyber Person (Software robot of human shaped) based on the technology of 3D-CG real-time animation and voice synthesis in e-learning system. He has published over 40 research papers in authoritative journals, international conferences, and books for the past 5 years.

J. Michael Spector is Chair of Learning Technologies in the College of Information at the University of North Texas. His recent research is in the areas of intelligent support for instructional design, system dynamics based learning environments, assessing learning in complex domains, distance learning, and technology integration in education. Dr. Spector served on the International Board of Standards for Training, Performance and Instruction (*IBSTPI*) as Executive Vice President; he is on the Executive Committee of the IEEE Learning Technology Technical Committee and is Past-President of the Association for Educational and Communications Technology (AECT). He is the editor of the Development Section of *Educational Technology Research & Development*, and he serves on numerous other editorial boards. He has coedited the third and fourth editions of the *Handbook of Research on Educational Communications and Technology*, and has more than 100 journal articles, book chapters, and books to his credit.

Qing Tan is an assistant professor in School of Computing and Information Systems at Athabasca University. Dr. Tan's background is in aviation navigation, control engineering, and computer information systems. As a Northwest Polytechnic University undergraduate in Xi'an, China, he majored in Gyroscopic and Inertial Navigation. Dr. Tan conducted his Ph.D. study at the Norwegian Institute of Technology in Trondheim. He then performed a senior research fellow at the Japan Atom Energy Research Institute. Dr. Tan worked in the IT industry for over 10 years in Canada. Dr. Tan's research interests include Location-Based Technologies, Mobile Computing, Mobile Learning, Wireless Sensor Networks, Computer Network and Cyber Security, Cloud Computing, and Robotics. Dr. Tan was one of the first people to introduce the location awareness of mobile devices into mobile learning applications. He, along with other coauthors, published it on a paper that has received an outstanding paper award. In addition, there are several location-based mobile applications that have been developed for enhancing collaborative and adaptive mobile learning. Overall, Dr. Tan's pioneer research is greatly impacting distance education and learning. He has also published and presented his research on location-aware technologies for mobile learning in wide range of international conferences and journals.

Alan S. Weber is an assistant professor of English who teaches the first-year Writing Seminar in humanities in the Pre-medical Program at Weill Cornell Medical College in Qatar. Dr. Weber previously taught literature, writing, and the history of science and medicine at Cornell University, Ithaca, The Pennsylvania State University, and Elmira College. His research interests include e-learning, language, history, and the social and cultural dimensions of science and medicine. He is the editor of *19th Century Science* (2000), and *Because It's There: A Celebration of Mountaineering Literature* (2001), and is the author of specialized publications on web-based learning in the Gulf Cooperation Council.

Leandro Krug Wives is an associate professor at UFRGS. He has a doctoral degree in Computer Science from UFRGS, and his research activities are related to text mining, web mining, and information extraction, retrieval, and recommendation.

Zhen Wu received her Ph.D. from University of Virginia. She has been conducting research on gender and computing during her graduate study. She joined NCWIT in 2011, where she is responsible for data management and analysis for evaluation programs.

Panagiotis Zervas has received a Diploma in Electronics and Computer Engineering from the Technical University of Crete, Greece, in 2002 and a master's degree in Computational Science from the Department of Informatics and Telecommunications of the National and Kapodistrian University of Athens, Greece, in 2004. Currently, he is a Ph.D. candidate at the Department of Digital Systems, University of Piraeus, Greece, and Member of the Informatics and Telematics Institute (ITI) of the Centre for Research and Technology Hellas (CERTH). His main scientific interests are in the areas of Technology-enhanced Learning. He is the coauthor of more than 40 publications in scientific journals and conferences. He has received the Best Poster Award in IEEE International Conference on Advanced Learning Technologies (July 2011), the Best Paper Award in the 2nd International Conference on Intelligent Networking and Collaborative Systems (2010), the Best Short Paper Award in IEEE International Conference on Advanced Learning Technologies (July 2009), and the Best Poster Award in IEEE International Conference on Advanced Learning Technologies (July 2007).

Reviewers

Name	Institution	Email
J. Enrique Agudo	University of Extremadura, Spain	jeagudo@unex.es
Thibault Carron	Université de Savoie, France	thibault.carron@univ-savoie.fr
Paula Ferreira	University of Extremadura, Spain	paula.br.fer@gmail.com
Said Hadjerrouit	University of Agder, Norway	said.hadjerrouit@uia.no
Kun Huang	UNTHSC Center for Learning & Development, USA	kun.huang@unthsc.edu
Yingdan Huang	University of Colorado, USA	yingdan.huang@colorado.edu
Tomayess Issa	Curtin Business School, Australia	tomayess.issa@cbs.curtin.edu.au
Jungmi Lee	Institut für Erziehungswissenschaft, Switzerland	jungmi.lee@ezw.uni-freiburg.de
Thomas Lehmann	Institut für Erziehungswissenschaft, Switzerland	thomas.lehmann@ezw.uni-freiburg.de
Pamela Leonard	Simulation and Training Environment Lab, USA	pamela.leonard@email.sitel.org
Alexander Libin	Simulation and Training Environment Lab, USA	alexander.libin@medstar.net
Jean-Charles Marty	Université de Savoie, France	Jean-Charles.Marty@univ-savoie.fr
Bente Meyer	Aarhus University, Denmark	bm@dpu.dk
Julian Moreno	National University of Colombia, Colombia	jmoreno1@unal.edu.co
Philippe Pernelle	Université de Lyon, France	philippe.pernelle@iutb.univ-lyon1.fr
Yoshiaki Shindo	Nippon Institute of Technology, Japan	shindo@nit.ac.jp
Alan Weber	Weill Cornell Medical College in Qatar, State of Qatar	alw2010@qatar-med.cornell.edu
Leandro Krug Wives	Universidade Federal do Rio Grande do Sul, Brazil	wives@inf.ufrgs.br
Bryan Yu Guo	Institute for Teaching & Learning Excellence, USA	bryan.guo@okstate.edu
Panagiotis Zervas	University of Piraeus & CERTH, Greece	pzervas@iti.gr

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Contents

Contributors

J. Enrique Agudo University of Extremadura, Badajoz, Spain

Urs-Vito Albrecht Hannover Medical School, Peter L. Reichertz Institute for Medical Informatics, Hannover, Germany

Lars Birch Andreasen Aalborg University, Aalborg, Denmark

Francisco Javier Arias Universidad Nacional de Colombia, Medellin, Colombia

Asya Asenova Sofia University, Sofia, Bulgaria

Hélvia Pereira Pinto Bastos Instituto Federal Fluminense, Campos dos Goytacazes, RJ, Brazil

Silvia Cristina Freitas Batista Instituto Federal Fluminense, Campos dos Goytacazes, RJ, Brazil

Patricia Alejandra Behar Universidade Federal do Rio Grande do Sul, Porto Alegre, RS, Brazil

Marianne Behrends Hannover Medical School, Peter L. Reichertz Institute for Medical Informatics, Hannover, Germany

Magda Bercht Universidade Federal do Rio Grande do Sul, Porto Alegre, RS, Brazil

Martha Burkle Athabasca University, Athabasca, AB, Canada

Thibault Carron Université de Savoie, Chambery Cedex, France

Julian Coppens University of Extremadura, Badajoz, Spain

Júlia Kikuye Kambara da Silva Universidade Federal do Rio Grande do Sul, Porto Alegre, RS, Brazil

Wendy DuBow National Center for Women & Information Technology, Boulder, CO, USA

Pavlin Dulev Sofia University, Sofia, Bulgaria

Michael Eisenberg Department of Computer Science, University of Colorado, Boulder, CO, USA

Ramón Fabregat Department of Computer Technology and Architecture (ATC), Polithechnic School, University of Girona, Girona, Spain

Paula Ferreira University of Extremadura, Badajoz, Spain

Sergio Gómez Department of Computer Technology and Architecture (ATC), Polithechnic School, University of Girona, Girona, Spain

Elissaveta Gourova Sofia University, Sofia, Bulgaria

Said Hadjerrouit University of Agder, Kristiansand, Norway

Birgitte Holm Sørensen Aalborg University, Aalborg, Denmark

Yingdan Huang Department of Computer Science, University of Colorado, Boulder, CO, USA

Dirk Ifenthaler University of Oklahoma, Norman, OK, USA

Pedro Isaias Universidade Aberta, Lisbon, Portugal

Ute von Jan Hannover Medical School, Peter L. Reichertz Institute for Medical Informatics, Hannover, Germany

Pamela Leonard SiTEL – Simulation and Training Environment Lab, MedStar Health, Washington, DC, USA

Alexander Libin MedStar Health Research Institute, Washington, DC, USA

Elena Libin SiTEL – Simulation and Training Environment Lab, MedStar Health, Washington, DC, USA

Tzu-Chien Liu National Central University, Taoyuan, Taiwan (R.O.C.)

Jean-Charles Marty Université de Savoie, Chambery Cedex, France

Hiroshi Matsuda Computer and Information Engineering, Nippon Institute of Technology, Miyashiro-machi, Minamisaitama-gun, Saitama, Japan

Herbert K. Matthies Hannover Medical School, Peter L. Reichertz Institute for Medical Informatics, Hannover, Germany

Bente Meyer Department of Computer Science, Aalborg University, Aalborg, Denmark

Jane Meyers University of Colorado, Boulder, CO, USA

Yuri Millo SiTEL – Simulation and Training Environment Lab, MedStar Health, Washington, DC, USA

Julian Moreno Universidad Nacional de Colombia, Medellin, Colombia

Demetrio Arturo Ovalle Universidad Nacional de Colombia, Medellin, Colombia

Liliana Maria Passerino Universidade Federal do Rio Grande do Sul, Porto Alegre, RS, Brazil

James W. Pellegrino University of Illinois, Chicago, IL, USA

Philippe Pernelle Université de Lyon, Lyon Cedex 07, France

Mercedes Rico University of Extremadura, Badajoz, Spain

Demetrios G. Sampson Information Technologies Institute (ITI), Centre for Research and Technology Hellas (CERTH)

Department of Digital Systems, University of Piraeus, Piraeus, Greece

Héctor Sánchez University of Extremadura, Badajoz, Spain

Yoshiaki Shindo Computer and Information Engineering, Nippon Institute of Technology, Miyashiro-machi, Minamisaitama-gun, Saitama, Japan

J. Michael Spector College of Information, University of North Texas, Denton, TX, USA

Qing Tan Athabasca University, Athabasca, AB, Canada

Alan S. Weber Weill Cornell Medical College in Qatar, Doha, State of Qatar

Leandro Krug Wives Universidade Federal do Rio Grande do Sul, Porto Alegre, RS, Brazil

Zhen Wu National Center for Women & Information Technology, Boulder, CO, USA

Panagiotis Zervas Information Technologies Institute (ITI),Centre for Research and Technology Hellas (CERTH)

Department of Digital Systems, University of Piraeus, Piraeus, Greece Piraeus, Greece

Part I
Context-Aware Adaptive and Personalized Systems for Formal and Informal Learning

Chapter 1
Context-Aware Adaptive and Personalized Mobile Learning Systems

Demetrios G. Sampson and Panagiotis Zervas

1.1 Introduction

Over the last decade, there is a growing interest about adaptive and personalized learning by many researchers in technology-enhanced learning (TeL) (Mulwa et al. 2010; Martins et al. 2008; Brusilovsky and Millán 2007; Brusilovsky and Paylo 2003). This has led to several research initiatives worldwide that investigate the potentials of the educational paradigm shift from the traditional one-size-fits-all teaching approaches to adaptive and personalized learning (Loa et al. 2012; Tseng et al. 2008; Brusilovsky and Henze 2007; Boticario and Santos 2007; Dagger et al. 2005). The key benefits of this approach are that learners are provided with adaptive and personalized learning experiences that are tailored to their particular educational needs and personal characteristics towards maximizing their satisfaction, learning speed, and learning effectiveness.

On the other hand, the widespread ownership of mobile devices and the growth of mobile communications industry have offered a number of benefits to the end users of mobile devices including (a) Internet access; (b) interpersonal and group text, voice, and/or video communication via wireless, cellular, and virtual private networks; (c) digital content sharing in various formats (text, image, audio, video); and (d) location-aware information delivery and personalized assistance according to end users' preferences, needs, and characteristics, all without place and device restrictions (Sharples and Roschelle 2010; Herrington et al. 2009).

D.G. Sampson (✉) • P. Zervas
Information Technologies Institute (ITI),
Centre for Research and Technology Hellas (CERTH)

Department of Digital Systems, University of Piraeus,
150, Androutsou Str., GR 185 32, Piraeus, Greece
e-mail: sampson@unipi.gr; pzervas@iti.gr

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Mobile devices are recognized as an emerging technology with the potential to facilitate teaching and learning strategies that exploit individual learners' context (Jeng et al. 2010; Johnson et al. 2009; Cobcroft et al. 2006). More precisely, mobile devices can (a) engage students to experiential and situated learning without place, time, and device restrictions; (b) enable students to continue learning activities, initiated inside the traditional classroom, outside the classroom through their constant and contextual interaction and communication with their classmates and/or their tutors; (c) support on-demand access to educational resources regardless of students' commitments; (d) allow new skills or knowledge to be immediately applied; and (e) extend traditional teacher-led classroom scenario with informal learning activities performed outside the classroom.

This has led to an increased interest on context-aware adaptive and personalized mobile learning systems that aim to provide learning experiences delivered via mobile devices and tailored to the educational needs, the personal characteristics, and the particular circumstances of the individual learner or a group of interconnected learners (Liu and Hwang 2009; Hwang et al. 2008; Yang 2006). The key benefits of these systems are that (a) learners are provided with personalized learning experiences in real-world situations and (b) learners' behavior is detected and recorded for providing them with adaptive feedback and support (scaffolding).

This chapter is an introduction to the field of context-aware adaptive and personalized mobile learning systems. This chapter is structured as follows. Following this introduction, Sect. 1.2 discusses the concept of context-aware adaptive and personalized mobile learning by presenting the different aspects that have to be considered when aiming at providing learners with adaptive and personalized learning experiences within context-aware mobile learning systems. Section 1.3 presents an overview of existing context-aware mobile learning systems and compares them based on the different aspects identified in Sect. 1.2. Finally, we discuss our main conclusions and ideas for future research in the area of context-aware mobile learning systems.

1.2 Context-Aware Adaptive and Personalized Mobile Learning

Mobile learning is defined as the process of learning and teaching that occurs with the use of mobile devices providing flexible on-demand access (without time and device constraints) to learning resources, experts, peers, and learning services from any place (Traxler 2009; Kukulska-Hulme 2009), and it is treated as part of ubiquitous learning, which is defined as "*the potential of computer technology to make learning possible at any time and at any place*" (Hwang 2006, p. 72). Ubiquitous learning anticipates a higher degree of embeddedness than mobile learning. This means that in ubiquitous learning, learners are supported by computers embedded in everyday objects during their learning process, whereas in mobile learning, learners are only supported by their mobile devices, which they are carrying with them (Liu and Hwang 2009).

The main benefits of mobile learning are reported as follows: (a) enables on-demand access to learning resources and services, as well as instant delivery of notifications and reminders (Ogata and Yano 2004), (b) offers new opportunities for learning that extend beyond the traditional teacher-led classroom-based activities (Kukulska-Hulme 2009), (c) encourages learners to participate more actively in the learning process by engaging them to experiential learning such as learning by doing (Herrington et al. 2009; Kukulska-Hulme 2009), (d) enables learning and performance support by exploiting real-life context (Kukulska-Hulme 2009; Lay 2007), and (e) supports on-demand access, communication, and exchange of knowledge with experts, peers, and communities of practice (Sharples and Roschelle 2010).

Adaptivity and personalization in mobile learning systems refers to the process of enabling the system to fit its behavior and functionalities to the educational needs (such as learning goals and interests), the personal characteristics (such as learning styles and different prior knowledge), and the particular circumstances (such as the current location and movements in the environment) of the individual learner or a group of interconnected learners (Wu et al. 2008). *Adaptivity* deals with taking learners' situation, educational needs, and personal characteristics into consideration in generating appropriately designed learning experiences, whereas *personalization* is a more general term and deals with the customization of the system features, including also issues which can be adapted and specified by learners themselves, such as the system interface, the preferred language, or other issues which make the system more personal (Martin and Carro 2009).

As a result, there are two main issues in the design of context-aware adaptive and personalized mobile learning systems, namely, the *learner's contextual information* that effects adaptations and the *type of adaptations* that can be performed based on learner's contextual information (Hong et al. 2009; Graf and Kinshuk 2008; Baldauf et al. 2007). Next, we discuss these two design issues in more details.

1.2.1 Learner's Contextual Information in Context-Aware Adaptive and Personalized Mobile Learning Systems

There are a number of research works that attempt to model learners' contextual information during the learning process (Das et al. 2010; Economides 2009; Hong and Cho 2008). A commonly used definition of *context* in computer science is "*any information that can be used to characterize the situation of an entity*" (Dey and Abowd 2000, pp. 3–4), where the term "*entity*" is defined as anything relevant (namely, a person, a place, or an object) participating in the interaction between a user and a system, and the term "*information*" is defined as any particular element or detailed piece of data that let describe any condition or state of the participating entities (Dey and Abowd 2000). In the field of TeL, context has been defined as "*the current situation of a person related to a learning activity*" (Luckin 2010, p. 15).

Table 1.1 Learning and mobile contextual elements (Zervas et al. 2011)

Dimensions	Elements
Learning context	
Learning design	Learning objectives, pedagogical strategy, learning activities, participating roles, tools, and learning resources
Learner profile	Competence profile (knowledge, skills, attitudes), role, and semipermanent personal characteristics (learning style, learning needs and interests, physical or other disabilities)
Mobile context	
Learner temporal information	Temporal personal information: mood, preferences, needs, and interests
People	Role, relationship, contributions, and constraints
Place	Location, zones, interactive space, cultural background, and learning setting
Artifact	Technological: physical properties and digital properties and non-technological
Time	Task duration, task scheduled, action happens, and availability
Physical conditions	Illumination level, noise level, and weather conditions

In previous works as reported in Zervas et al. (2011), existing efforts have been studied for modeling learner's contextual information in mobile learning systems, and a context model has been considered, which can be used in mobile learning systems for personalization and adaptation. More specifically, this context model has been developed based on previous work by Siadaty et al. (2008), who considered that context can be divided into (a) the learning context and (b) the mobile context. The learning context is defined by the learners, the educational resources, the learning activities, and the specific pedagogical strategy, whereas the mobile context is defined by the learning context captured with regard to its delivery medium (i.e., the mobile devices). Christopoulou (2008) has proposed to model mobile context according to five dimensions, namely, user temporal information, place, artifact, time, and physical conditions. Our context model combines and further elaborates the dimensions and their specific elements of both categories (i.e., learning and mobile context). The main dimensions and the elements of this context model are presented in Table 1.1.

As we can notice from Table 1.1, *learning context* can be described by the elements of a particular learning design and the elements of the individual learner's profile. More precisely, a learning design is defined as "*the description of the teaching-learning process, which follows a specific pedagogical strategy or practice that takes place in a unit of learning (e.g., a course, a learning activity or any other designed learning event) towards addressing specific learning objectives, for a specific target group in a specific context or subject domain*" (Koper and Olivier 2004, p. 98), whereas learner's profile includes elements such as (a) learner's competence profile, which contains a set of knowledge, skills, and attitudes, and (b) learner's semipermanent personal characteristics, which include learning style, learning needs and interests, as well as physical or other disabilities (Li et al. 2010; Brown et al. 2009).

Additionally, *mobile context* can be described by the elements of (a) learner's temporal information including his/her mood, interests, needs, and preferences that reflect his/her temporal degree of willingness to participate in the learning process; (b) other people that influence the learning process with their role, relationships, contributions, and constraints, and they are related with the current circumstances; (c) current location including geospatial information, zones (small places inside bigger places, for example, a library inside a university), interactive spaces (such as public and private spaces), cultural background (such as physical and social conditions of an environment), and learning setting (such as lab-based, work-based); (d) technological artifacts (such as mobile devices, smartboards) and non-technological artifacts (such as a book or anything non-technological that can used for learning); (e) current time conditions such as duration of a task, scheduled time of a task, history of learner's actions performed, and time availability of the learner, a peer, or an expert; and (f) physical conditions (such as illumination level, noise level, and weather conditions) where the learning process is taking place.

1.2.2 Types of Adaptation in Context-Aware Adaptive and Personalized Mobile Learning Systems

Based on relevant studies in the literature, we can identify two main categories of adaptation in context-aware adaptive and personalized mobile learning systems (Economides 2009; Graf and Kinshuk 2008): (a) one related to educational resources and (b) another related to learning activities. Next, we present in details these two (2) categories:

(a) *Types of adaptation related to educational resources:*

- *Selection*: This type of adaptation deals with selecting appropriate educational resources and presenting them to the learners based on different selection criteria derived from learners' contextual elements. More precisely, typical selection criteria include (1) combination of learner's current location, availability, and learner's previous knowledge, as proposed by Yau and Joy (2008), and (2) combination of learner's current location, availability, scheduled tasks, duration of tasks, and learner's previous knowledge, as proposed by Chen and Li (2010).
- *Presentation*: This type of adaptation considers that educational resources is adaptively structured for access via mobile devices by taking into account (1) parameters related with the learners' type of mobile device in use and the learner's profile (including learner's preferences and learning style), as proposed by Bomsdorf (2005), and (2) parameters related with learner's location, physical conditions, and learner's temporal information (Graf et al. 2008; Gómez and Fabregat 2010). Different presentation forms of educational

resources include (a) changing the format for the same type of educational resource (e.g., wav files to mp3 files), (b) changing the type of the educational resource (e.g., to visual or audio presentation instead of textual presentation), and (c) changing the dimensions of the educational resource (e.g., scaling down or scaling up the dimensions of the educational resource) (Zhao et al. 2008; Bomsdorf 2005).

– *Navigation and sequencing*: This type of adaptation rearranges or reorders the navigation and sequencing possibilities of different educational resources that are linked to each other towards creating personalized learning paths by taking into account different criteria derived from learners' contextual elements. More precisely, typical criteria include (1) the combination of learner's previous knowledge, availability, and current location, as proposed by Cui and Bull (2005), and (2) the combination of learner's previous knowledge, needs, preferences, availability, current location, and learner's temporal information as proposed by Nguyen et al. (2010).

(b) *Types of adaptation related to learning activities*:

– *General adaptation*: This type of adaptation deals with automatic generation of individual learning activities based on different criteria derived from learners' contextual elements as described in Table 1.1. More precisely, automatic generation of learning activities includes (a) adaptations to the educational resources, tools, and services that support the learning activities and (b) adaptations to the roles that participate to the learning activities (Gómez et al. 2012).

– *Feedback and support (scaffolding)*: This type of adaptation includes personalized hints at the right time and suggestion of suitable learning activities depending on different criteria derived from learner's contextual elements. More precisely, typical criteria include (1) learner's location (Ogata et al. 2005; Paredes et al. 2005) and (2) learner's location and learner's previous knowledge (Al-Mekhlafi et al. 2009; Liu 2009; Yin et al. 2010).

– *Navigation to locations*: This type of adaptation includes mostly location awareness and planning of suitable learning activities in real-world situations (e.g., during a museum visit or an execution of an experiment in a laboratory). More specifically, learners can be guided and perform location-dependent learning activities according to a dynamically structured navigation path, which is constructed based on (1) current learner's location (Hwang et al. 2008) and (2) the combination of current leaner's location and learner's previous knowledge (Tan et al. 2009; Hwang et al. 2009).

– *Communication and interaction*: This type of adaptation facilitates learners during the execution of learning activities in (1) finding peers based on their location with whom they can meet virtually, build learning groups, and share knowledge or experts with whom they can communicate for asking advice or help for specific issues (Martin et al. 2008; Tan et al. 2009) and (2) selecting appropriate communication and collaboration tools based on learners' preferences and needs (Economides 2008).

In the next section, we provide an overview of existing context-aware mobile learning systems, and we classify them based on (a) the learner's contextual information that they process and (b) the adaptations that they perform following the adaptation types identified in this section.

1.3 Overview of Context-Aware Adaptive and Personalized Mobile Learning Systems

A system is considered as context-aware if it can extract, interpret, and use *context information* and *adapt its behavior and functionalities* to the current context of use (Byun and Cheverst 2004). In Sect. 1.2, we discussed the concept of learner's contextual information (which is considered as the input to context-aware mobile learning systems) as well as the types of adaptation (which are considered as the output of context-aware mobile learning systems). Next, we provide an overview of context-aware mobile learning systems based on the input that they process following the classification of learners' contextual information as discussed in Sect. 1.2.1 and the output that they provide to the learners following the classification of adaptation types as discussed in Sect. 1.2.2:

(a) *Context-aware mobile learning systems that perform adaptations to educational resources*:
   - *Selection*: (1) mCALS (Yau and Joy 2008) is a context-aware mobile learning system that aims to support Java programming learning and selects appropriate educational resources for presenting them to the learner based on the combination of learner's current location, availability, and previous knowledge, and (2) PCULS (Chen and Li 2010) is a context-aware mobile learning system that aims to support English vocabulary learning and selects appropriate educational resources for presenting them to the learner based on the combination of learner's current location, availability, scheduled tasks, duration of tasks, and previous knowledge.
   - *Presentation*: (1) A context-aware mobile learning system has been proposed by Bomsdorf (2005) focusing on adapting the presentation of educational resources presented to the learners by transforming the format, the type, and the dimensions of educational resources based on the type of learner's mobile device, the learner's preferences, and the learning style, and (2) similar context-aware mobile learning systems have been proposed by Graf et al. (2008) and Gómez and Fabregat (2010), which perform similar transformations to the presentation of the educational resources, but they also exploit learner's location, physical conditions, and learner's temporal information.
   - *Navigation and sequencing*: (1) TenseITS (Cui and Bull 2005) is a context-aware mobile learning system that aims to support English language learning and adapts the sequence and navigation of its educational resources based on

the combination of learner's previous knowledge, availability, and current location, and (2) CAMLES (Nguyen et al. 2010) is another context-aware mobile learning system that aims to support English language learning and adapts the sequence and navigation of its educational resources based on the combination of learner's previous knowledge, needs, preferences, availability, current location, and temporal information.

(b) *Context-aware mobile learning systems that perform adaptations to learning activities*:

- *General adaptation*: A prototype context-aware mobile learning system has been developed by Gómez et al. (2012), which semiautomatically adapts individual learning activities based on the dimensions of learner's contextual information described in Table 1.1.
- *Feedback and support (scaffolding)*: (1) TANGO (Ogata et al. 2005) is a context-aware mobile learning system that aims to support English language learning and provides adaptive feedback and support based on learners' location. Another similar context-aware mobile learning system is LOCH (Paredes et al. 2005) that aims to support Japanese language learning and provides adaptive feedback and support to the learners based on their location, and (2) CAMCLL (Al-Mekhlafi et al. 2009) is a context-aware mobile learning system that aims to support Chinese language and provides adaptive feedback and support to the learners based on learner's location and learner's previous knowledge. Other similar context-aware mobile learning systems are the HELLO (Liu 2009), which aims to support English language learning based on learner's location and learner's previous knowledge, and JAPELAS2 (Yin et al. 2010), which aims to support Japanese language politeness learning based on learner's location and learner's previous knowledge.
- *Navigation to locations*: (1) A context-aware mobile learning system has been proposed by Hwang et al. (2008), which automatically constructs a navigation path to perform certain learning activities in a university campus based on learner's location, and (2) Tan et al. (2009) describe a context-aware mobile learning system that automatically constructs a navigation path to perform certain learning activities in a university campus according to learners' previous knowledge and learner's location. Moreover, Hwang et al. (2009) present a similar context-aware mobile learning system that automatically navigates learners to conduct learning activities within a laboratory and by exploiting learners' previous knowledge and learner's location.
- *Communication and interaction*: (1) A context-aware mobile learning system has been proposed by Martin et al. (2008), which gives information about people who are close to the learner by exploiting learner's location during the execution of learning activities in a university campus, and (2) a context-aware mobile learning system has been proposed by Economides (2008), which automatically selects appropriate communication and collaboration tools by exploiting learners' preferences and needs.

Table 1.2 compares existing context-aware mobile learning systems according to the different dimensions of the learner's contextual information that they process. Learner's contextual information is divided into two main categories (namely, learning context and mobile context), in accordance with the categories and the dimensions of these categories described in Table 1.1.

As we can notice from Table 1.2, each context-aware mobile learning system produces a reflection of its own perception on how learner's contextual information should be described towards providing adaptive features to the learners. This results to different descriptions of learner's contextual information, which cannot be adopted and used between various context-aware mobile learning systems. This raises an important interoperability problem that needs further consideration and research. Moreover, we can notice that there are limited context-aware mobile learning systems that perform automatic adaptation of learning activities in general, whereas for all other adaptation types, there are several context-aware mobile learning systems that have been developed from past research works in adaptive hypermedia, without considering the particularities of mobile learning.

1.4 Future Research Directions

Based on the systematic comparison of existing context-aware mobile learning systems presented in this book chapter, an important issue for future research is the definition and the representation of a thorough context model for describing learner's contextual information in a commonly agreed manner that can be interexchanged between context-aware mobile learning systems. This will enable building a common framework for context-aware mobile learning systems that can be adopted and used among various context-aware mobile learning systems. The outcome of this research direction will assist educational system developers to build context-aware mobile learning systems following this common framework towards providing interoperability among these systems.

Another challenging issue for future research is the automatic generation of individual learning activities in context-aware mobile systems. There are research works that investigate this issue in TeL systems without specific considerations for context-aware mobile learning systems (Charlton and Magoulas 2011; Drira et al. in press). The outcome of this research direction can assist design and delivery of more effective personalized learning experiences to individual learners.

1.5 Conclusions

Context-aware mobile learning is an emerging and promising research field, which can benefit strongly by considering personalization and adaptivity aspects towards providing more effective, convenient, and enhanced learning experi-

Table 1.2 Comparison of existing context-aware mobile learning systems

Adaptation type	Context-aware mobile learning systems	Learning context		Mobile context					
		Learning design	Learner profile	Learner temporal informa-tion	People	Place	Artifact	Time	Physical conditions
Educational resources: selection	mCALS (Yau and Joy 2008)	–	√	–	–	√	–	√	–
	PCULS (Chen and Li 2010)	–	√	–	–	√	–	√	–
Educational resources: presentation	Bomsdorf (2005)	–	√	–	–	–	√	–	–
	Graf et al. (2008)	–	√	–	–	√	√	–	√
	Gómez and Fabregat (2010)	–	√	√	–	√	√	–	√
Educational resources: navigation and sequencing	TenseITS (Cui and Bull 2005)	–	√	–	–	√	–	√	–
	CAMLES (Nguyen et al. 2010)	–	√	√	–	√	–	√	–
Learning activities: general adaptation	Gómez et al. (2012)	√	√	√	√	√	√	√	√
Learning activities: feedback and support (scaffolding)	TANGO (Ogata et al. 2005)	–	–	–	–	√	–	–	–
	LOCH (Paredes et al. 2005)	–	–	–	–	√	–	–	–
	CAMCLL (Al-Mekhlafi et al. 2009)	–	√	–	–	√	–	–	–
	HELLO (Liu 2009)	–	√	–	–	√	–	–	–
	JAPELAS2 (Yin et al. 2010)	–	√	–	–	√	–	–	–

Learning activities: navigation to locations	Hwang et al. (2008)	–	–	–	–	√	–	–	–
	Tan et al. (2009)	–	√	–	–	√	–	–	–
	Hwang et al. (2009)	–	√	–	–	√	–	–	–
Learning activities: communication and interaction	Martin et al. (2008)	–	–	–	–	□	–	–	–
	Economides (2008)	–	√	√	–	–	–	–	–

ences. This book chapter targets to provide an overview of the field of context-aware adaptive and personalized mobile learning systems and contribute a structured comparison of existing context-aware mobile learning systems by discussing the learner's contextual information that these systems are processing and the adaptation types that are performed in these systems.

This book chapter can facilitate (a) educational systems developers during the process of developing new context-aware mobile learning systems by providing them an overview of current developments in the field, (b) instructional designers during the process of selecting appropriate context-aware mobile learning systems for designing personalized learning experiences for individual learners, and (c) researchers in the field of context-aware mobile learning for researching and providing solutions to open research issues as described in Sect. 1.4.

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Chapter 2
Cloud Computing in Education

Alan S. Weber

2.1 Introduction

Cloud computing promises many benefits for educators and students: centralized computer systems can process large amounts of data, specifically graphics; manage complicated functions; and store enormous amounts of keyword searchable data, while users can access this information and interact with other users with low-cost simple devices such as smartphones, tablets, and notebooks. Economies of scale insure that these services can now be delivered at a lower cost than institutions can provide with in-house mainframe computers. However, the business models of some cloud vendors, both commercial and educational, have serious flaws in that they often rely on advertising revenue by monetizing a user's browsing habits and other potentially personally identifiable information such as device IDs, IP addresses, photographs, etc. in addition to the standard registration information gathered such as name, physical location (zip code), and e-mail addresses. In the current climate, there is no mechanism to require corporations in the USA to reveal how they are using this data.

Although most cloud companies claim that they anonymize personally identifiable data or only use aggregated statistics, the possibility of indentifying a specific user based on only 3–5 pieces of basic information is now a trivial exercise, particularly as the amount of publicly available information on the Internet increases. For example, Latanya Sweeney at Carnegie Mellon University demonstrated in 2000 that 53% of the US population could be uniquely identified with only three common pieces of information: place (zip code), gender, and date of birth (Sweeney 2000). Thus, the danger has arisen that student educational records, test scores, health status, and browsing habits (online searches) that expose health status, social behav-

A.S. Weber (✉)
Weill Cornell Medical College in Qatar, Doha, Qatar
e-mail: alw2010@qatar-med.cornell.edu

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iors, or psychological state could be maliciously or accidentally disclosed or treated as a marketable quantity without adequate regulatory oversight when students use educational tools in the cloud. Therefore, educational institutions in the USA and abroad must now rely on terms of service agreements and their trust in a particular company not to abuse personal data and to protect them from external threats of disclosure and internal malicious insiders. A more rational approach would be to extend strict data protection laws, such as the Children's Online and Privacy Protection Act (COPPA) and Health Information Portability and Accountability Act (HIPAA), to all personal electronic data. Also, monies for enforcement should be increased as well as the powers of the Federal Trade Commission (FTC), which regulates Internet privacy. Most privacy violations are never investigated by the FTC, and large corporations who violate current laws are receiving a slap on the wrist, except in the case of unauthorized health information disclosure which incurs heavy fines.

Apple Corporation recently introduced its iCloud platform, marketed primarily for music storage, joining established cloud vendors such as Amazon.com (EC2 and S3), Microsoft (Windows Azure), and Google (Google Apps, Gmail), demonstrating that large technology corporations are rushing to establish market share in this new arena. Millions of users are already in the cloud if they use Google Apps, Hotmail, Yahoo! Mail, or Gmail (software as a service). Due to cost savings, educational institutions are also increasingly looking to cloud services for educational purposes, such as running learning management systems, modules, and graphics-based virtual classrooms hosted on cloud-based systems such as Linden Labs Second Life service.

However, along with this rise in hosted services, serious concerns from government, educators, and privacy experts have developed. A 2009 EDUCAUSE survey of 372 member educational institutions demonstrated that 42.1% were outsourcing their learning management systems and 29.1% their e-mail services: interestingly, only 6.5% reported outsourcing of data storage (Goldstein 2009, p. 4). A number of cloud-based e-learning systems are already in operation, such as BlueSky cloud framework at Xi'an Jiaotong University in China (Dong et al. 2009a, b) and Cloud Infrastructure and Applications or CloudIA at The Hochschule Furtwangen University in Germany (Doelitzscher et al. 2011), in addition to initiatives in Japan, Malaysia, and the USA (Rajam et al. 2010; Razak 2009; Chine 2010). The most frequent problems consistently cited about cloud computing in recent surveys of business and government leaders are security, privacy, user trust, and legal compliance with existing data protection laws.

Although this chapter will focus on the USA where privacy has been largely self-regulated by corporations until very recently, the information will be of interest internationally since many of the large cloud vendors are US-based and store data on US servers subject to US law. Although the US-EU & US-Swiss Safe Harbor Frameworks were developed to bridge the stricter EU data and privacy protection laws and the US self-regulatory approach in transnational transmission and storage of personal data, the Safe Harbor process of self-certification has led to numerous violations and lackluster enforcement by the Federal Trade Commission (CEC 2002; Connolly 2008). An increasing number of public revelations that hosted services and cloud vendors have been collecting and selling personal data as part of their business model, and the use by these companies of new tracking technologies such as geolocation, face recognition software, collocation algorithms, aggregation of data across accounts, and various deceptive practices such as restoring deleted cookies has led to three major proposed revisions of current privacy laws: changes to the US Child Online Privacy Protection Act (COPPA) suggested in 2011 (FTC), the US White House policy paper endorsed by Barack Obama entitled *Consumer Data Privacy in a Networked World* (The White House 2012), and the EU's proposed 2012 Data Protection Reform. In response to the White House paper, the Digital Advertising Alliance (DAA), a group that self-regulates Online Behavioral Advertising, immediately announced that it would begin working with browser developers to create an opt-out button to prevent Internet tracking of consumers. Online tracking through cookies, super cookies, and flash shared objects across multiple sites using data aggregation by third-party analytics companies and advertisers represents one of the greatest current risks to the privacy of users of cloud services.

2.2 Pros and Cons of Educational Cloud Computing

2.2.1 What Is Cloud Computing?

The global management consulting firm McKinsey uncovered 22 possible separate definitions of cloud computing. "In fact, no common standard or definition for cloud computing seems to exist" (Sultan 2010, p. 2). Cloud computing is similar to, but vastly more advanced than, the older mainframe model of computing dominant in the 1960s–1980s in which a large, centralized mainframe computer executed functions while users inputted and outputted commands and data with "dumb" terminals (also called "thin clients") physically connected to the mainframe. These terminals were essentially keyboards and monitors with minimal storage capacity and minimal or nonexistent ability to run software applications. Today's cloud architectures take advantage of advancements in grid computing and virtualization: multiple operating systems can operate simultaneously in a layer, and on top of that layer, multiple normally incompatible software applications; data migration is faster and more efficient, storage space can be more efficiently allocated, resources are distributed and can be recalled on demand rapidly, and resources are quickly scalable to meet variable demand, etc.

For the sake of simplicity, Furht's definition adequately summarizes the essentials of cloud computing: "Cloud computing can be defined as a new style of computing in which dynamically scalable and often virtualized resources are provided as a service over the Internet" (Furht 2010, p. 3). Cloud computing capabilities are usually categorized into three areas: (1) *IaaS*—Infrastructure as a Service represents the computing layer of physical hardware, servers, and networking components; (2) *PaaS*—Platform as a Service provides an environment and framework (system), including development tools, in which software applications can be run; and (3)

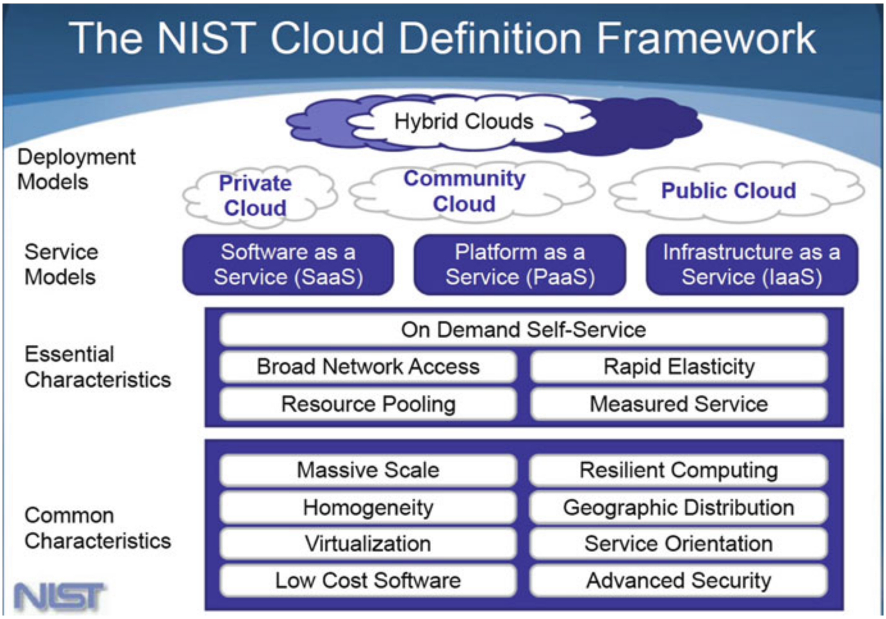

Fig. 2.1 NIST Cloud Framework (Reproduced from Mell and Grance 2009)

SaaS —Software as a Service, one of the most common uses of cloud computing, consists of software services such as e-mail, word processing, and spreadsheets available from online cloud services instead of running these applications directly on local client computers (Furht 2010, pp. 5–6; Katzan 2010, pp. 3–4). Google Apps and Google Docs are two of the most popular public software as a service offerings. The diagram above; developed by Peter Mell and Tim Grance at the National Institute of Standards and Technology (NIST) graphically summarizes the major components and types of cloud computing (Mell and Grance 2009) (Fig. 2.1).

2.2.2 *Benefits of Cloud Computing*

One of the greatest advantages of cloud computing for educational institutions is cost savings as many vendors offer pay-as-you-go schemes: customers pay for CPU hours or gigabits (Gbs) consumed or transferred (Gbps). In addition, there are generally no installation, upgrade, bug fix, or patch costs for software incurred by the purchaser. Billing structures are similar to public utilities like water and electricity. Simplification of software licenses and upgrades saves considerable IT administrative time (Ercan 2010). The supplier maintains and upgrades both hardware and software resources and the user pays for these services depending on the amount of usage, which can be easily scaled to accommodate rapidly changing needs or peak demand periods in an organization. Architecture scalability is achieved through full- or para-virtualization, such that multiple operating systems can be run at the same time on a virtual machine or across multiple machines.

From a developer standpoint, IT technicians often complain that they do not have enough physical resources such as storage and processing power to test and disseminate large, new systems while simultaneously operating their existing system: cloud computing can fill this important need. Also, data centers consume a tremendous amount of energy for cooling and electricity to power hardware and to cool machines, and cloud computer proponents argue that the centralization of resources saves energy due to improved efficiencies. A white paper from Microsoft Corporation in collaboration with Accenture and WSP reports that “Microsoft’s cloud solutions can reduce energy use and carbon emissions by more than 30% when compared to their corresponding Microsoft business applications installed on-premise” (Microsoft, Inc. 2010, p. 3). This finding is important for educational institutions which should be in the vanguard of promoting socially and ethically responsible uses of technology. A widely quoted figure in the industry itself claims that IT services produce approximately 2% of the world’s carbon emissions (Dedrick 2010, p. 11).

From an educational standpoint, popular hosted and social networking services such as Facebook and Google are easy to use, ubiquitous, in many cases free of charge, and can greatly facilitate communication between teachers and students if managed properly by classroom codes of conduct, rules, and proper use of privacy settings. These services can now provide many of the basic educational features and content initially offered by learning management systems such as Blackboard, Angel, and Moodle including posted text (class reading materials), student exchanges and debates (bulletin board or e-mail), instructional videos, and links to other web resources. Social networking is also highly entertaining, which some educators will define as a plus in keeping students engaged in learning, while others will condemn as a distraction or frivolous. It is highly debatable whether social networking increases or retards social skills and language development, since many real-world language cues such as eye contact, body language, and tonal variation are lost, unless live video chat is being employed. However, novel online linguistic features such as emoticons and new online dialectical language variants such as *arabizi* (Arabic slang written in Romanized alphanumeric Arabic script) demonstrate that technology is shaping language use at an unprecedented rate and scale. For schools in the developing world, use of free hosted services such as Google’s Gmail accounts will boil down to cost savings. For example, a school can provide free e-mail accounts for all students that will take care of most educational needs of communicating among administrators, parents, teachers, and students.

2.2.3 Security and Privacy Issues in Cloud Computing

Leavitt Communications, Inc., reports that “a recent survey of chief information officers and IT executives by market-research firm IDC rated security as their main cloud-computing concern. Almost 75% of respondents said they were worried about security" (Leavitt 2009, p. 4). The US federal government would like to invest more heavily in cloud services, but the 2010 US federal budget cites security concerns: "the federal community will need to actively put in place new security measures which will allow dynamic application use and information-sharing to be implemented in a secure fashion (United States Federal Budget 2010, p. 157)" (as cited in Paquette et al. 2010, p. 4). The White House's Consumer Data Privacy paper specifically notes that the USA is a world leader in the export of cloud computing and location-based services, but both national and international consumers must have faith in data privacy protection when using these services, or they will cease to use them (p. 6). In February 2012, both EU's Justice Commissioner Viviane Reding and the French data regulator CNIL announced that the proposed changes to the privacy policies of Google, one of the world's largest cloud operations, failed to meet the requirements of the European Data Protection Directive (95/46/CE). These recent disagreements underscore the immense legal complexity of transborder data movement facilitated by cloud computing (Pearson 2011).

For older Internet users, financial record compromise and identity theft, along with revelation of health status, are central concerns, but apparently these are not pressing problems for the younger Facebook generation who have been brought up giving out personal information online on a regular basis. Furnell, however, believes that younger social networking users may be uninformed about information privacy risks and may lack "an understanding of how such data may be exploited in the wrong hands (e.g., simply not realizing that sharing the combination of date of birth, contact information, and certain family details can give someone else a good start on the road towards committing identify theft)" (Furnell and Botha 2011, p. 14). The general concept of privacy varies greatly across cultures; for example, in Arabic-speaking countries and the Middle East, personal behavior is closely tied to family, group, and tribal honor, and reputation must be carefully guarded, especially in online environments (Weber 2010, 2011). Privacy in the USA is protected by a mixture of constitutional Bill of Rights amendments, legal precedent ("right to be left alone"), and privacy laws, with public figures receiving diminished protections of privacy. In some authoritarian states, individuals have no expectation of freedom from intrusion from their government in any aspect of their lives.

Online identity theft and personal data revelation can lead to financial loss, as well as cyberbullying, and possible stalking and the danger of predators. Also, lack of trust in cloud solutions due to data abuses hampers innovation in creating new cloud-based educational solutions and e-learning initiatives (NTIA 2010, p.1). Without data protections in place and laws such as the Family Educational Rights and Privacy Act (FERPA), student educational records as well as psychological counseling or medical records could be in jeopardy of becoming public information in unsecured environments or organizations with poor internal oversight policies. In fact, simply migrating records to the cloud can often change their legal status with concomitant loss of protections. In June 2011, a software bug allowed anyone to log into someone else's account on the popular cloud storage provider Dropbox, allowing access to all of their data. Also, certain tracked online activity such as searching for health information on a specific disease via a cloud search engine such as Yahoo or

Google Search in essence creates a kind of loose "health record" that can be bought and sold to interested corporations, especially if augmented with aggregated data from ancillary services owned by the same company, such as data-mined Google Gmails to one's healthcare provider.

The cloud vendor would argue that it is on firm legal grounds to carry out this kind of aggregation because it is allowed by the terms of service agreed to by the customer of the cloud service and there is in fact no mechanism or regulation that requires the vendor to divulge this kind of practice unless served with legal action. Four watchdog groups in 2010 in fact filed a complaint with the FTC entitled "Online Health and Pharmaceutical Marketing that Threatens Consumer Privacy and Engages in Unfair and Deceptive Practices" arguing that personal data collected by websites could no longer be realistically de-identified or anonymized. Students under the age of 13 face similar privacy threats about their personal information gathered through tracking, and the FTC has fined a number of companies in the past 3 years for violations of COPPA. Much of this data collection activity operates outside of regulatory scrutiny and is often uncovered and exposed by security experts and university researchers.

The World Privacy Forum (WPF) did a comprehensive survey of privacy concerns related to public cloud computing in 2009. According to Gellman, the author of the WPF report, "for some types of information and some categories of cloud computing users, privacy and confidentiality rights, obligations, and status may change when a user discloses information to a cloud provider. Procedural or substantive barriers may prevent or limit the disclosure of some records to third parties, including cloud computing providers. For example, health record privacy laws may require a formal agreement before any sharing of records is lawful" (Gellman 2009, p. 6). The information from profiling gathered by extensive online tracking of Internet users by companies (not limited to cloud vendors) can be used to deceive online consumers via targeted ads into making fraudulent, harmful, or unnecessary purchases or to be denied the right to purchase certain products or at inflated prices proportional to their income (geo-targeted pricing).

An individual's loss of control of such information as health status could lead to serious consequences such as job loss and discrimination in housing and obtaining health insurance. For example, an employer discovers that an employee is being treated for addiction to illegal substances and automatically terminates employment according to its antidrug policies. The problem with decontextualized information shared without the originator's consent is that it can be easily misinterpreted, and specialized circumstances cannot be explained or qualified by the originator of the data. In the case of students, the public revelation of criminal activity as a minor or past treatment for psychological ailments or behavioral problems could haunt the individual for the rest of his or her life and impact their future development. A new consumer movement, reiterated by the proposed EU reforms, of "the right to be deleted" or "right to be forgotten" is growing, but many current cloud vendor policies claim rights over user posted data in perpetuity. Deleting information on most cloud services merely means it becomes invisible to other users, but it is still retained by the service in backup copies, including entire accounts. This situation is troubling from an educational standpoint, because young people often experiment and push the boundaries of both real-world and online behavior, and youthful indiscretions can be a learning experience, but mistakes made early in life should not necessarily be recorded forever.

Although these are obvious observations, social media such as Facebook and information services such as Google are both actively and surreptitiously (e.g., leaving privacy settings open by default) encouraging users to give out more and more personally identifiable information on publicly accessible websites and claiming rights to retain it in perpetuity since the basis of a large percentage of their profits consists of organizing, analyzing, packaging, and selling information, or subcontracting with data analytics companies to allow mining of this information. Twitter's announcement in February 2012 that it would be selling a 2-year archive of tweets to data analysis companies sparked condemnation from privacy experts. Facebook's recent IPO filing (Initial Public Offering) revealed that the company is essentially an advertiser, achieving the majority of its profits from selling advertisements. Educators who wish to piggyback educational ideas and systems onto commercial social networking sites should be aware of the business model of the company and should know that most platforms are not designed with educational use in mind nor are most platforms especially compatible for healthcare applications. Even social networking sites specifically designed for education, such as Edmodo, which provides some of the more privacy-friendly educational web tools, must be scrutinized. As per US law, Edmodo adheres strictly to COPPA for collection of personal data on under-13s, but conspicuously in its terms of service, Edmodo does not extend these protections to all users. Its copyright policy is almost identical to Facebook's, and it retains the right to generate derivative works from any content uploaded to it. Thus, the business model of Edmodo appears to include offering paid premium services in addition to data mining user content for business ideas. Also, although Edmodo claims that it does not rent or sell personal information, it does treat this information explicitly as a business asset, and users must agree to the condition that personal information may be transferred to an acquiror: "in the unlikely event that Edmodo goes out of business or enters bankruptcy, user information would be one of the assets that is transferred or acquired by a third party. You acknowledge that such transfers may occur, and that any acquiror of Edmodo may continue to use your Personal Information and Children's Personal Information as set forth in this policy" (Edmodo 2012). To reiterate, this privacy policy may not be of concern to some educators and educational administrators, but if any institution is worried that they may lose control of PII or educationally sensitive material upon sale of Edmodo, current US law will not protect them (only through an ineffective formal complaint to the FTC), except for information from under-13s protected by COPPA.

Top officials of companies—including Google and Facebook—whose profit derives from monetizing personal information (primarily for behavioral or targeted marketing) have been dismissive and even contemptuous of privacy efforts to secure private data on the Internet, exemplified by the famous comment of Sun Microsystems' CEO Scott McNealy concerning Internet privacy in 1999 that individuals have zero privacy on the Internet and they should "get over it."

Although McNealy is in some sense correct, users can maintain some privacy and anonymity on the Internet, and they have a reasonable expectation thereof analogous to personal privacies protected in everyday life. Pearson believes that a major privacy risk for cloud users, and one that can be protected against ↑ is "being forced or persuaded to be tracked or give personal information against their will, or in a way in which they feel uncomfortable" (Pearson 2009, p. 4). The terms of service of many of the large cloud vendors disqualify these services from the protections of the Secured Communications Act (SCA), which would place restrictions on how vendors could access and use third-party information on their servers. A review in the *Georgetown Law Journal* of cloud computing business models and online privacy protections with respect to the SCA and the more comprehensive Electronic Communications Privacy Act (ECPA) concluded: "the advertising supported business model embraced by many cloud computing providers will not qualify for the SCA's privacy protections. In exchange for 'free' cloud computing services, customers are authorizing service providers to access their data to tailor contextual and targeted advertising. This quid pro quo violates the SCA's requirements and many customers will find that their expectations of privacy were illusory. Consequently, a cloud provider's terms of service agreement may be the only privacy protections applicable to its customers" (Robinson 2010, p. 2). Similarly, non-US cloud users must ensure that the weak protections in the USA do not compromise their own stricter data protection laws: for example, the UK Data Protection Act (DPA) of 1998 prevents UK organizations from transferring personal and health data outside of the EU. US cloud providers are increasingly responding to these concerns by physically locating servers in various countries with more restrictive data laws. The US-EU Safe Harbor Framework also attempts to address this problem.

When making decisions about moving personal data to the cloud, educational institutions need to investigate specifically how this data will be protected in transmission and storage from phishing, pharming, packet sniffing, traffic analysis, and other cyber attacks. Threats to data can be both external and internal, sometimes arising inside the cloud datacenter or service itself. Unfortunately, large US cloud vendors and corporations storing sensitive data, such as banks, have not been entirely transparent in providing details about past cyber attacks and how and what specific data were compromised (partially to prevent copycat attacks). With the merging of social media and virtual learning environments—that is, collaborative learning using multimedia and the concept of sharing—privacy and security become more serious and complicated issues. For example, Carnegie Mellon University Professor Alessandro Acquisti, who earlier demonstrated that a person's social security number could be predicted based on publicly available online information, recently developed software to uncover a person's name, birth date, and social security number by taking an electronic photograph of a random person and matching it with Facebook profile pictures using facial recognition software (Daily Mail Reporter 2011).

Some IT researchers such as Pocatilu and Tchifilionova, however, argue that cloud computing can be inherently more secure than current distributed client models due to data fragmentation and dispersal, improved and centralized ability to provide advanced security such as firewalls and filters, greater resiliency and faster restoration of services and data loss, and real-time vigilance (24/7 human and automated monitoring) against network attack and system tampering (Pocatilu et al. 2009, p. 56; Tchifilionova

2011). Itani, for example, asks why cloud computing should not be as secure and private as in-house IT department systems and proposes (and provides technical details of) a "privacy as a service" model: "We believe that data privacy should be provided to cloud customers as a service with minimal additional cost. Moreover, we believe that the cloud privacy model should be configurable and user-centric. That is, the cloud customer should be able to flexibly control and manage the different privacy mechanisms necessary to protect sensitive data and achieve legal compliance" (Itani et al. 2009, p. 1). Several other researchers have proposed comprehensive security systems for cloud providers, for example, Santos's *trusted cloud computing platform* (TCCP) (Santos et al. 2009), TrustCloud from Hewlett-Packard Labs (Ko et al. 2011), and three trust mechanisms detailed in Krautheim's 2010 PhD thesis.

2.2.4 Case Study of Internal Abuse of Centralized Technology: Lower Merion School District "WebcamGate"

A cautionary tale with strong analogies to cloud computing issues (centralization of resources, privacy protection, internal abuse) surfaced in 2009 when it was discovered that IT technicians at two schools near Philadelphia, Pennsylvania, apparently with approval from school officials, had remotely activated webcams on high school student laptops, snapping over 66,000 pictures and screenshots and recording browsing histories while the students were in their homes or bedrooms. The webcams were activated using preinstalled LANrev ThefTrack software for detecting laptop theft. The actions were discovered when 15-year-old Blake Robbins was confronted by a school vice-principal for inappropriate behavior at home based on a webcam photo taken unbeknownst to him in his bedroom. After Robbins' parents complained to the school about the false accusations, an investigation uncovered that webcams had been activated in student homes even when laptops had not been reported stolen, that images were deleted from servers when legal action was brought against the school, and that some of the images may have captured underage children in various stages of undress, a violation of child pornography laws. Robbins' parents filed civil suit against Lower Marion School District for violating the Electronic Communications Privacy Act ("ECPA"), Computer Fraud and Abuse Act ("CFAA"), Stored Communications Act ("SCA"), and the Pennsylvania Wiretapping and Electronic Surveillance Act ("PWESA") (*Robbins* 2010, p. 2). The school district reached an out-of-court settlement with Robbins and Jalil Hasan, another student, for $610,000 USD. The FBI opened an investigation, but closed it after determining that criminal intent could not be firmly established (FBI 2010).

The salient features of the case are as follows: since all laptops were connected to the same server, surveillance could be centralized and systematized. The school district lacked clear policies about the use of the TheftTrack feature, analogous to lack of transparency in cloud vendors' terms of service. Images were shared among school officials and technicians, again without clear policy oversight. In several instances of the use of TheftTrack, investigators could not determine why the feature was turned on (in one case continuously for 2 weeks) when laptops had not been reported stolen, thus leading to the conclusion that the feature was possibly being abused for unknown purposes (internal abuse).

Internal abuse, in other words the "malicious insider," is a growing concern with such vendors as Google who do not encrypt stored data such as Gmail and whose corporate ethics have sometimes been questionable in the past, such as knowingly violating US copyright laws during the early stages of Google Books and capturing e-mail addresses and log-ins from unsecured Wifi networks using its street view cars. The Cloud Security Alliance, an industry consortium dedicated to solving the serious security and trust issues still troubling the industry, ranked "malicious insider" as its #3 threat (CSA 2010). Hiring and screening policies, as well as access levels and monitoring of cloud employees, are not often transparent or regulated, and cyber-criminals including organized criminals and political and industrial spies will find infiltrating a cloud data center posing as a legitimate employee immensely attractive. Or conversely, an initially honest employee with high-level clearance who realizes the value of this new gold mine of aggregated personal data may be tempted to copy and sell some of this data on the black market. Opponents of the US REAL ID bill (which would create a highly detailed national centralized database of drivers' licenses) have argued that the very existence of a large centralized database of personally identifiable information in and of itself constitutes a serious security risk.

In the Lower Merion School District, students were required to use the school-issued laptops (personal laptops were confiscated on school property), a situation strongly analogous to vendor lock-in, discussed below. Most disturbingly, the FBI could not bring any of the aforementioned federal or state online privacy or data protection laws to bear on the case, including wiretapping, invasion of privacy, and computer abuse, or unwarranted surveillance demonstrating that individual privacy may not be adequately safeguarded by existing federal legislation. In response to the shocking allegations that arose from the Lower Merion School District case, US Senator Arlen Specter (D-PA) called for stronger federal wiretapping and video-voyeurism legislation. Video voyeurism and disclosure of personal information (invasion of privacy) can have real-world and devastating effects, such as the suicide of Tyler Clementi in 2010 after his roommate viewed him with a webcam in a homosexual encounter via iChat.

2.2.5 Loss of Data Control and Intellectual Property Rights

On December 31, 2008, Google's 2-year experimental online virtual world Lively was closed. The site held great potential for virtual classroom development and e-learning. It is unknown how much educational development time was invested in by users on the site, but the existing data was not easily exportable, that is, educational content may have been permanently lost with the closure of Lively. Lively officially announced to its loyal users: "We'd encourage all Lively users to capture your hard work by taking videos and screenshots of your rooms" (Heater 2008). The potential discontinuation of cloud services and recoverability of data is a serious concern for educators who migrate learning systems or learning objects to cloud platforms and services as most cloud vendors in their terms of service reserve the right to discontinue services at any time for any reason. Also, a further risk is discontinuation of service for allegedly violating the terms of service or existing laws: if a user or organization is mistakenly or unjustly barred access to their data, how are disputes resolved and what is the status of the existing data? As Gellman notes in a World Privacy Forum study, "The terms of service may allow a cloud provider to terminate services to a user at any time. The result could be that a user who did not maintain a full backup of information stored in the cloud may lose the information permanently" (Gellman 2009, p. 18). Also, a cloud company could be sold, or enter bankruptcy without knowledge of the user.

Another potential concern in using some cloud services for educational purposes involves the loss of rights to intellectual property and copyright. Copyright in the digital age is a considerably murky area, as laws and concepts promulgated in the nineteenth century could not have foreseen the ease with which almost any form of audio or visual or written content can be easily digitized and distributed almost instantaneously over electronic networks. By simply posting educational content to a hosted cloud service, users may be surrendering their property rights to the content (Onwubiko 2010, p.16). Google's universal terms of service regarding copyright, for example, appear contradictory in that users "retain copyright and any other rights you already hold in Content." However, the next lines of the terms state: "By submitting, posting or displaying the content you give Google a perpetual, irrevocable, worldwide, royalty-free, and non-exclusive license to reproduce, adapt, modify, translate, publish, publicly perform, publicly display and distribute any Content which you submit, post or display on or through, the Services."

The plain English interpretation of these terms seems to indicate that the user is either relinquishing exclusive copyright or sharing copyright with Google. The author has not uncovered any copyright court cases involving Google and individual users that have reached the federal level, but such cases, including class action suits, are looming for cloud vendors, particularly if they change terms of services and attempt to profit directly from user-generated copyrighted material. Facebook, which is increasingly being used for educational purposes, has almost identical copyright policies. As Gellman notes: a "user may not be able to take comfort when a cloud provider does not currently claim rights over the user's data. A cloud provider could change the terms of service and privacy policy at any time" (Gellman 2009, p. 18).

2.2.6 Miscellaneous Barriers

Cloud computing generally requires broadband (high speed) Internet to be most effective, but this service is not available or reasonably priced in some parts of the world. There are additional potential concerns with networking latency (delays in accessing and transmitting data) related to the Internet infrastructure available to an organization, a key concern for countries with insufficient bandwidth. Some aspects of cloud computing such as splitting data structures into elements can hinder digital forensics (inability of law enforcement to find, capture, or track data linked to internal abuses and cybercrime) (Garfinkel 2010, p. S66).

Vendor lock-in or proprietary lock-in refers to the practice of forcing clients to continue using a company's products or services because changing vendors would be too expensive or technologically unfeasible (monopoly on a product or service). Wheeler and Waggener note: "what if a campus wants to exit a relationship with a commercial cloud service provider? Is that simple, or are commercial cloud computing models a guise, as noted by *The Economist*, for a new form of vendor lock-in through very high switching costs?" (Wheeler and Waggener 2009, p. 5). Richard Stallman, an Internet privacy advocate who founded the Free Software Foundation and developed the GNU operating system, described cloud computing as "a trap aimed at forcing people to buy into locked, proprietary systems that are likely to prove costly in the future" (as cited in Johnson 2008). Larry Ellison, the founder of Oracle, has expressed similar concerns and believes, like Stallman, that cloud computing has been redefined to mean all the advancements that have already occurred in the computer industry as opposed to a new computing paradigm (Sultan 2010, p. 5).

Additionally, using multiple cloud vendor contracts could result in a complicated, difficult to administer scenario for an organization, especially if one vendor changes technical specifications or terms of service that impact other services. This consideration makes single vendor comprehensive solutions attractive, exposing users to monopolistic behavior by the cloud vendor. One solution to all of these problems is to use hybrid clouds by developing a privacy, security, and confidentiality data decision table or grid (mission critical, confidential, sensitive, etc.): mission critical and highly confidential information could be stored on-site or in private encrypted clouds controlled by the end-user, while less important data could be migrated to the public cloud (i.e., routine e-mail or scheduling services). Many organizations now employ this model (Mircea and Andreescu 2011, p. 10). Open source software, such as the course management software Moodle, provides some of the same cost-saving benefits as cloud services but allows greater institutional control of security and privacy since the software can be run locally.

2.2.7 Lessons Learned: Best Practices in Educational Cloud Computing

There appear to be few technical reasons why cloud computing could not be as safe, secure, and trusted as in-house educational platforms. The reasons why public cloud computing vendors have not made adjustments to their business models and practices (such as controlling and limiting collection of PII, encrypting data, collecting data only within specific contexts, limiting internal access to data, and offering more individual control over data) to embrace both the educational and healthcare sector markets is not entirely clear. A number of possible hypotheses include (1) encryption adds extra costs, reduces flexibility in distributing data across servers, can slow down systems, and can cause irretrievable data loss if users forget access keys; (2) educators are not sufficiently concerned about privacy to demand more stringent controls; (3) cloud vendors are not sufficiently concerned with the health and education markets as of yet since proprietary software, such as course management systems in education and custom-built electronic medical records (EMR) systems in health care, are a preferred choice; and (4) some cloud business models specifically capitalize on user-supplied private data. However, Amazon Web Services claim that HIPAA-compliant health data systems, which require strict data accountability, have been built on their cloud platforms. Also, researchers at the University of Piraeus are developing secure context-aware authorization systems for cloud-based and mobile systems (Poulymenopoulou et al. 2011).

Given the current situation in which security and privacy issues in cloud computing in education have not been entirely resolved by US cloud vendors, what should US and international educators who want to take advantage of the many benefits of cloud computing and public hosted services do? First, institutional legal teams should scrutinize the terms of service and privacy policies of services to make sure that they do not violate national law or school policy, and secure specialized agreements to prevent such problems. For example, the author's own institution Cornell University successfully negotiated with Google to provide student e-mail accounts (Gmail) with enhanced privacy: Google agreed not to access any Cornell e-mail, web, or productivity application content on Google servers, in essence complying with Cornell's stringent privacy protections. Unless such specific security and privacy provisions are made by the institution either by contractual agreement or by security practice (e.g., following Amazon Web Services recommendations that clients encrypt data on top of the virtualization layer), mission critical educational data should not be stored in the cloud, that is, grades, educational records, high stakes testing scores, health data related to students, or data relating to counseling or disciplinary actions. Students should be provided with explicit personal security training in using the Internet, both for educational settings and outside of school. Many US institutions have basic policies about school computer use, but now the privacy situation in schools must be more thoroughly addressed by IT staff. Also, as proven by the Lower Merion School District case, school IT staff themselves need to be trained and monitored according to privacy and security policies.

Students should be taught how to limit the personal information that a website collects and stores about them (i.e., train students to delete or block third-party cookies); and they should also be taught about privacy best practices, for example, not giving out their telephone number, physical address, and financial information to untrusted individuals. In addition, IT staff can set up school browsers with preferred privacy settings or parental controls and lock students out of altering preferences.

2.2.8 Further Areas of Research

Educators who are concerned about privacy, if they belong to large institutions who may be able to influence cloud corporations, should be more proactive in voicing their concerns directly to the cloud service providers and bodies such as the Cloud Security Alliance. Unfortunately, only a small number of organizations such as the World

Privacy Forum and Electronic Frontier Foundation appear to be active in attempting to secure privacy rights and freedom from surveillance and misuse of data. Research into more user-friendly, faster, and secure encryption and authentication schemes is needed; encryption should be the default means of handling any sensitive or personally identifiable Internet data. More unbiased cross-sectional studies of attitudes towards data privacy need to be conducted: many current studies are biased and unreliable because respondents, particularly younger students, are not sufficiently knowledgeable about how the Internet works to answer questions intelligently. Questions should clearly explain the salient issues in plain language, for example, Likert-scale items in the form of: "How concerned would you be if a corporation did *xyz* with a list of the websites that you looked at on your computer?"

2.3 Conclusions

Clearly, stricter laws which include more transparency about what exactly public cloud corporations are doing with personal information are needed in the United States. The White House's suggested consumer online privacy framework issued in February 2012 urges Congress to enact legislation according to the White House-suggested principles. In this scheme, the Federal Trade Commission would be the regulatory body responsible for enforcing infractions. Also, new laws on electronic communication which take into account the latest technological advances such as face recognition software and browser fingerprinting would be welcome—this situation impacts international technology users since many large cloud vendors are located in the USA and store their data on US servers. In the current chaotic and loose US regulatory climate of online data, educational institutions must carefully scrutinize terms of service of cloud vendors and balance cost savings versus potential violations of existing privacy or data protection laws, specifically student records and personally identifiable health information of students (US laws, such as HIPAA and HITECH, are exceptionally strict in this regard with substantial fines for each individual data breach). If social media such as Facebook is used for educational purposes, students should be trained in the use of the complicated privacy settings. Also, general Internet safety and security should be part of required school curricula. If the cloud computing industry cannot solve these issues in the way that the finance and e-commerce sectors have successfully dealt with online trust, security, and privacy, then cloud vendors will miss out on major IT markets including health care and education where privacy and confidentiality are of paramount importance. With proper protections in place, cloud computing could provide cost-effective, environmentally friendly, secure, and up-to-date learning environments particularly attractive to developing nations.

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Chapter 3
Designing Tools for Context-Aware Mobile Educational Content Adaptation

Panagiotis Zervas, Demetrios G. Sampson, Sergio Gómez, and Ramón Fabregat

3.1 Introduction and Problem Definition

Over the past years, the widespread ownership of mobile devices and the growth of mobile communications industry have led to new m-services including Internet access; interpersonal and group communication without place, time, and device restrictions; sharing of digital content in any format (text, image, audio, and video); location-aware information delivery; and personalized assistance based on user preferences and needs (Sharples and Roschelle 2010; Herrington et al. 2009). These services facilitated by mobile devices can be also exploited for educational purposes aiming to enhance traditional classroom-based and/or desktop-based web-facilitated educational experiences. This has led to research and educational initiatives that investigate the potential of mobile learning (Kukulska-Hulme et al. 2009, 2011; Ally 2009).

Nevertheless, most of existing digital educational resources are currently developed considering desktop PCs as the delivery end, increasing the barriers of learners in accessing resources through their mobile devices (Su et al. 2011; Zhao et al. 2008). As a result, the issue of mobile content adaptation has been raised (Gómez and Fabregat 2012). An important issue for designing appropriate mobile content

P. Zervas (✉) • D.G. Sampson
Information Technologies Institute (ITI),
Centre for Research and Technology Hellas (CERTH)

Department of Digital Systems, University of Piraeus,
150, Androutsou Str., GR 185 32, Piraeus, Greece
e-mail: pzervas@iti.gr; sampson@unipi.gr

S. Gómez • R. Fabregat
Department of Computer Technology and Architecture (ATC),
Polithechnic School, University of Girona, Av. Lluis Santalo s/n, 17071 Girona, Spain
e-mail: sergiog@silver.udg.edu; ramon.fabregat@udg.edu

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adaptation mechanisms is the exploitation of learner's mobile contextual information (Madjarov and Boucelma 2010; Bhaskar and Govindarajulu 2009).

As a result, different types of mobile content adaptation have been proposed. More specifically, these types of mobile content adaptation include (a) adaptive content navigation and sequencing (Nguyen et al. 2010), adaptive content transformation (Zhao et al. 2008; Bomsdorf 2005), and adaptive content filtering (Bomsdorf 2005). However, existing mechanisms for context-aware mobile content adaptation follow hardwired implementations of their adaptation engines based on predefined instances of learners' mobile contextual information. Consequently, this impedes the process of (a) extending the adaptation engines with new instances of learners' mobile contextual information and (b) interexchanging these engines and their resultant types of mobile content adaptation with other adaptive learning systems and applications. Additionally, all existing approaches consider that context-aware mobile content adaptation is implemented in real time during the mobile delivery process, which in most cases delays significantly the process of presenting adapted educational resources to the learners' mobile devices.

A possible solution to these issues could be the formal description of the adaptation engines by using a notation language that is independent of the particular implementation of the mobile content adaptation mechanism in hand. A possible implementation of this solution could be the adoption of the IMS Learning Design (LD) specification (IMS Global Learning Consortium 2003), which has been proposed as a possible notation language for describing learning designs as well as accompanying educational content-based adaptations in the form of rules and following a machine-readable format (Martínez-Ortiz et al. 2009; Specht and Burgos 2007). However, this approach has not been exploited for considering the particularities of context-aware mobile content adaptation processes. To this end, in this book chapter, we present (a) a context-aware mobile educational content adaptation mechanism and a subsequent process, which utilize IMS LD as the enabling specification for describing the adaptation engine (in the form of adaptation rules) of the proposed mechanism and (b) a set of design requirements for tools that enable authoring and delivering of context-aware learning designs with mobile content adaptation features.

This book chapter is structured as follows. Following this introduction, Sect. 3.2 discusses the main components of a mobile educational content adaptation mechanism and presents our proposed approach for a mobile educational content mechanism. Section 3.3 presents the proposed mobile educational content adaptation processes that are implemented based on the proposed mobile educational content adaptation mechanism described in Sect. 3.2. Section 3.4 presents design requirements for two tools that can support the mobile educational content adaptation processes described in Sect. 3.3. Finally, we discuss our main conclusions and ideas for further work.

3.2 Context-Aware Mobile Educational Content Adaptation Mechanism

The key components (see Fig. 3.1) of a context-aware mobile educational content adaptation mechanism are the input (namely, learner's mobile context), the adaptation engine, and the output (namely, types of mobile content adaptation) (Su et al. 2011; Fudzee and

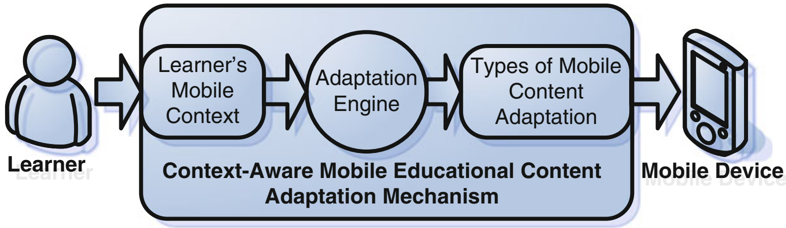

Fig. 3.1 Context-aware mobile educational content adaptation mechanism

Abawajy 2008). Next, we describe in more detail each one of these components, and we present our proposed mobile educational content adaptation mechanism.

3.2.1 Learner's Mobile Contextual Information

A widely used definition of context in computer science is "any information that can be used to characterize the situation of an entity" (Dey and Abowd 2000, pp. 3–4). In the field of technology-enhanced learning (TeL), learning context has been defined by Luckin (2010, p. 15) as "the current situation of a person related to a learning activity." In response to the particularities of mobile devices, Siadaty et al. (2008) have proposed to divide context into (a) the learning context and (b) the mobile context. The learning context is defined by the learners, the educational resources, the learning activities, and the specific pedagogical strategy, whereas the mobile context is defined by the learning context captured with regard to its delivery medium (i.e., the mobile devices) (Siadaty et al. 2008). Christopoulou (2008) has proposed to model mobile context according to five dimensions, namely, learner's temporal information, place, device, time, and physical conditions. Table 3.1 presents in more detail these dimensions.

In our work, we adopt the dimensions presented in Table 3.1, as the key dimensions for modeling learner's mobile context towards constructing our mobile educational content adaptation mechanism.

3.2.2 Adaptation Engine

The adaptation engine acquires input data and produces the adaptation results. Input data into the adaptation engine is the *learner's mobile context*. Output results of the adaptation engine are the adapted mobile educational content (Economides 2009). There are several approaches in the field of mobile content adaptation for implementing adaptation engines, which include:

- *Adaptation rules*, that is, when the resultant types of mobile content adaptation are derived from conditional structures of if/then/else statements, which are

Table 3.1 Learner's mobile contextual elements

Learner's mobile context	
Dimensions	Description
Learner's temporal information	This dimension includes learner's preferences and needs that reflect his/her temporal degree of willingness to participate in the learning process
Place	This dimension includes geospatial information about learner's current location
Device	This dimension includes information about the technical capabilities of the learner's mobile device
Time	This dimension includes information about current time conditions and learner's available time
Physical conditions	This dimension includes information about the physical environment conditions such as illumination level, noise level, and weather conditions where the learning process is taking place

based on the instances of learner's mobile context dimensions (Arai and Tolle 2011; Al-Hmouz and Freeman 2010; Bhaskar and Govindarajulu 2009).

- *Adaptation algorithms*, that is, when the resultant types of mobile content adaptation are derived from different types of algorithms such as heuristic algorithms, similarity algorithms, and decision-based algorithms, which are processing the instances of learner's mobile context dimensions (Su et al. 2011; Madjarov and Boucelma 2010; Zhao et al. 2008).

Nevertheless, existing approaches follow hardwired implementations of their adaptation engines, which are based on predefined instances of a learner's mobile contextual dimensions. As a result, adaptation engines cannot be extended with new instances of learners' contextual dimensions towards providing more accurate educational content adaptations to the learner's mobile devices. Furthermore, hardwired implementations of adaptation engines limit their potential to be inter-exchanged and transferred to other adaptive learning systems, and they keep them embedded (local) to the particular system in hand. Finally, these approaches consider dynamic adaptation, which adapts the educational content in real time during the learner's request, and in some cases (especially during adaptive content transformation), this introduces significant delays to the delivery of adapted educational content to learner's mobile device.

A possible solution to these problems could be the formal description of the adaptation engines by using a notation language that is independent of the particular implementation of the mobile content adaptation mechanism in hand. This will enhance the flexibility of these engines in terms of extensions and inter-exchange with other systems and applications. A possible implementation of this solution could be the adoption of IMS Learning Design (LD) specification, which has been proposed as a notation language for describing learning designs (IMS Global Learning Consortium 2003). A learning design is defined as "the description of the teaching-learning process, which follows a specific pedagogical strategy or practice that takes place in a unit of learning (e.g., a course, a learning activity or any other designed learning event) towards addressing specific learning objectives, for a specific target group in a specific context or subject domain" (Koper and Olivier 2004, p. 98).

In IMS LD, a learning design can be built at three different levels (level A, level B, and level C). At level A, learning designs include a series of learning activities, performed by one or more actors/roles, in an environment consisting of educational resources and/or services. Level B adds properties (storing information about a person or a group) and conditions (placing constraints with rules upon learning flow), and level C adds notifications that can facilitate reconfiguring design based on runtime events (Koper and Burgos 2005). Considering this, IMS LD can be used for describing in a machine-readable format content adaptation rules (based on different instances of a learner's mobile context dimensions), which can produce different types of mobile content adaptation during the mobile delivery process. In this book chapter, we propose the adoption of IMS LD specification for modeling in a machine-readable format the mobile content adaptation rules of the adaptation engine of our proposed mechanism.

3.2.3 Types of Mobile Content Adaptation

Based on relevant studies in the literature, we can identify three main types of mobile content adaptation, which are (a) content filtering (Bomsdorf 2005), (b) content transformation (Zhao et al. 2008; Bomsdorf 2005), and (c) content navigation and sequencing (Nguyen et al. 2010). Next, we present in detail these types of mobile content adaptation:

- Content filtering: This type of content adaptation deals with selecting appropriate educational resources and presenting them to the learners based on learner's mobile context dimensions (Bomsdorf 2005).
- Content transformation: This type of adaptation considers that educational resources' presentation is adaptively transformed for access via different mobile devices (Zhao et al. 2008; Bomsdorf 2005). Different transformation mechanisms include (Mirri 2007) (a) converting the format for the same type of educational resources (e.g., wav files can be converted to mp3 files); (b) converting the type of the educational resources, such as converting text to speech (text-to-speech) or vice versa (speech-to-text), or converting animated images to still images; and (c) changing the dimensions of the educational resources (e.g., scaling down or scaling up the dimensions of the educational resource).

- Content navigation and sequencing: This type of content adaptation rearranges or reorders the navigation and sequencing possibilities of different educational resources that are linked to each other towards creating resource-based personalized learning paths (Nguyen et al. 2010).

In our proposed mobile educational content adaptation mechanism, we consider *content filtering* and *content transformation* as key types of mobile content adaptation within the design and the implementation of learning activities represented with IMS LD. More specifically, content filtering consists of making selections by using IMS LD level B conditional statements to evaluate learner's mobile contextual dimensions in order to show or hide available educational resources. Finally, content transformation allows customizing the file format or the properties of the educational resources, which are populating the learning activities of a learning design, according to different parameters based on the capabilities of the specific mobile device in hand.

3.3 Context-Aware Mobile Educational Content Adaptation Process

The study of relevant literature on context-aware mobile content adaptation processes reveals that these processes traditionally take place during run time and they usually consist of three main phases (see Fig. 3.2), which are (Arai and Tolle 2011; Bhaskar and Govindarajulu 2009):

- Detect learner's mobile context dimensions: During this phase, learner's mobile context dimensions are detected by hardware and the sensors of the mobile device or it can be entered by the learner.
- Mobile content adaptation execution: During this phase, the learner's mobile context dimensions are evaluated by the adaptation engine and appropriate types of mobile content adaptation (as described in Sect. 3.2.2) are applied in real time. Especially for the content transformation type, this is implemented with a transcoding process, which receives requests from the adaptation engine and sends responses with transformed content (Gómez and Fabregat 2010; Zhao et al. 2008).
- Adapted mobile content delivery: During this phase, the results of the different types of mobile content adaptation performed in the previous phase are presented to the learner's mobile device.

However, this context-aware mobile content adaptation process could introduce significant delays to the phase of delivering adapted educational resources to the learner's mobile devices, because of previous delays in the phase of applying in real time different types of mobile content adaptation. The context-aware mobile educational content adaptation process that we adopt aims to overcome this limitation and takes place at two levels: (a) at *design-time* level, where con-

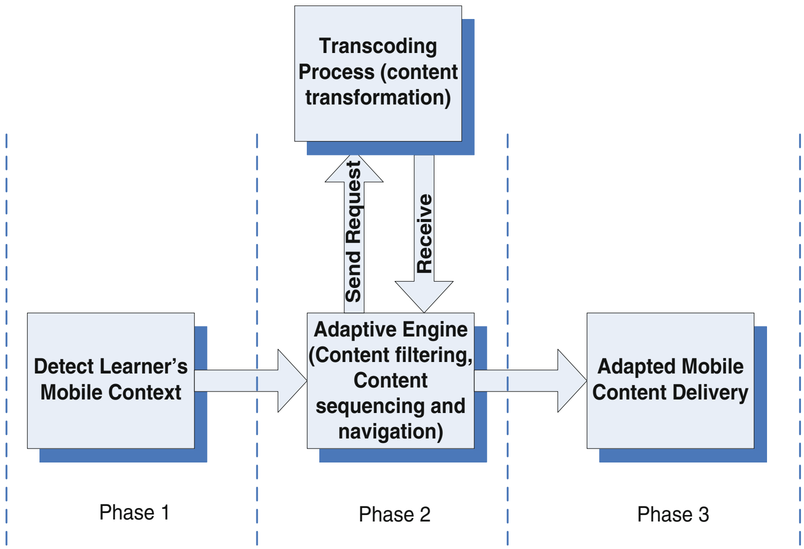

Fig. 3.2 Mobile educational content adaptation process

text-aware learning designs are developed including content adaptation rules for different types of mobile devices and (b) at *run-time* level, where predefined context-aware learning designs (from design-time level) can be instantly delivered based on detected type of the learner's mobile device. Next, we describe in more detail the phases of our proposed context-aware mobile educational content adaptation process at both levels.

3.3.1 Design-Time Level

At design-time level (see Fig. 3.3), there are three main phases, which are described below:

- Learning design authoring: During this phase, a learning design can be authored including adaptation rules based on learner's mobile context dimensions that can be detected from the learner's mobile device and include learner's temporal information, place, time, and physical conditions. An example of an adaptation rule could be as follows: if the learner's temporal preference is to receive easy educational resources and his/her location is a cafeteria and time is later than 21:00 p.m. and illumination level is low, then present him/her with an easy exercise with big letters and bright colors and hide difficult educational resources with small letters and dark colors.
- Dynamic content transformation: During this phase, educational resources that have been used in the previous phase for populating the developed learning

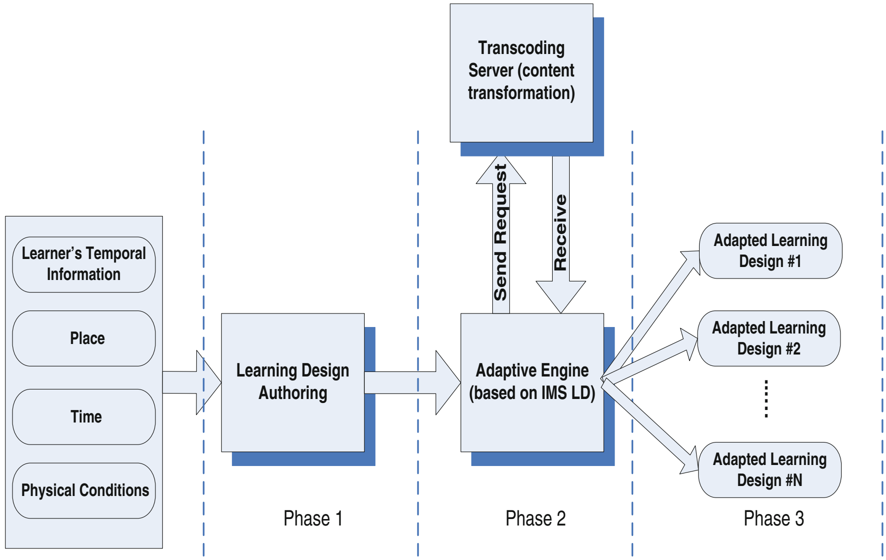

Fig. 3.3 Mobile educational content adaptation process at design-time level

design are transcoded with the use of a transcoding server and according to different parameters of the different mobile devices. The transcoding process consists of a set of steps to transcode the properties (format, type, size dimensions, quality, etc.) of educational resource elements by considering the technical capabilities of a mobile device (i.e., browser, network connection, display, media support). This transcoding process as well as validation results about the transcoded version of the educational resources has been presented in Gómez and Fabregat (2012).

- Adapted learning designs creation: During the final phase, a number of different adapted context-aware learning designs are created (one per each type of mobile device) populated with the transcoded version of educational resources suitable for the specific type of mobile device.

3.3.2 Run-Time Level

At run-time level (see Fig. 3.4), there are three main phases, which are described below:

- Detection: During this phase, learner's mobile context dimensions, namely, learner's temporal information, place, device, time, and physical conditions, are detected by the learner's mobile device or they can be entered by the learner himself/herself.

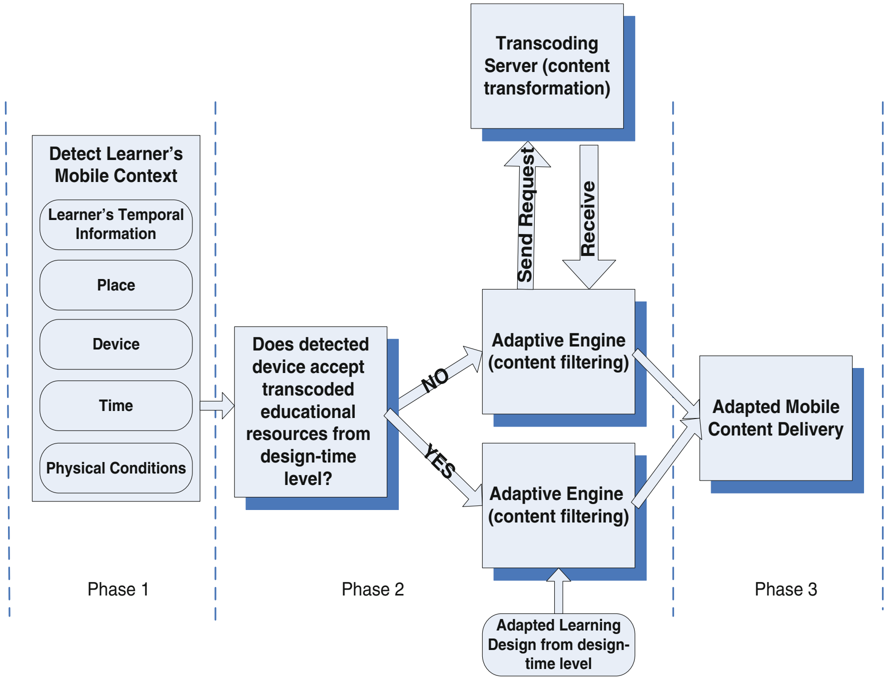

Fig. 3.4 Mobile educational content adaptation process at run-time level

- Mobile content adaptation execution: During this phase and based on the detected mobile device capabilities, it is evaluated whether learner's mobile device is capable of delivering the transcoded educational resources created during design time. If this is the case, then an adapted context-aware learning design created during design time is instantly delivered to learner's mobile device. Otherwise, a similar transcoding process as in design time is executed so as to transcode the educational resources for populating the current learning design. Moreover, content-filtering adaptation rules of the current learning design are executed based on the learner's mobile context information related to learner's temporal information, place, time, and physical conditions.
- Adapted mobile content delivery: During the final phase, the results of content transformation and content filtering performed in the previous phase are presented to the learner's mobile device.

As we can notice, the presented context-aware mobile educational content adaptation process at run time can benefit from the results of the corresponding process at design-time level. This is due to the fact that the transcoding process at run time can be avoided if a learner's mobile device can deliver already transcoded educational resources that have been developed during design-time level. Consequently, this can significantly reduce the time of delivering adapted mobile educational content to a learner's mobile device.

3.4 Tools for Context-Aware Mobile Educational Content Adaptation

In Sect. 3.3, we discussed the different phases of the proposed context-aware mobile educational content adaptation process, which take place at two levels, namely, at design-time and at run-time level. In this section, we present design requirements for two tools that are needed to facilitate the proposed mobile educational content adaptation process at both levels. More precisely, we present design requirements for (a) an authoring tool that facilitates authoring of context-aware learning designs (compatible with the IMS LD specification) with content adaptation rules for educational resources filtering and transformation and (b) a mobile delivery tool that facilitates delivery of context-aware learning designs (compatible with the IMS LD specification) with content adaptation rules for educational resources filtering and transformation.

3.4.1 Authoring Context-Aware Learning Designs

The design requirements of an authoring tool for context-aware learning designs (compatible with the IMS LD specification) that incorporate content adaptation rules for educational resources filtering and transformation could be summarized as follows:

- Requirement 1: The author should be able to define appropriate content adaptation rules according to the different values of the learner's mobile context dimensions (as defined in Sect. 3.2.1) for the entire learning design. These rules should be inherited by all the learning activities, which constitute the learning design. This functionality aims to reduce the effort for defining content adaptation rules as well as to provide a consistent way to define content adaptation rules for all learning activities that constitute the learning design.
- Requirement 2: The author should be able to define content adaptation rules for each individual learning activity that a learning design incorporates. This is necessary, since the educational resources of an individual learning activity may need to be adapted based on different adaptation rules from those defined for the entire learning design, when specific learner's mobile contextual conditions are detected. This functionality aims to enhance flexibility for defining adaptation rules.
- Requirement 3: The author should be able to create profiles of content adaptation rules (for certain values of learner's mobile context dimensions), which can be used during the authoring process of a new learning deign. This requirement enables end users to reuse profiles of content adaptation rules among different learning designs.
- Requirement 4: The tool should have the capability to automatically transform the content adaptation rules inserted by the author to IMS LD properties and conditions and save this information to the produced IMS LD XML manifest,

which is exported by the tool. This requirement is important because it makes this process accessible to non-XML experienced users.
- Requirement 5: The author should be able to graphically design learning designs based on the interconnection of user-defined learning activities. This requirement makes the learning design process efficient and user-friendly.
- Requirement 6: The tool should provide the capability to directly assign educational resources to the learning activities of the learning design. This should be facilitated by providing access to learning object repositories (LORs) with recommendations facilities about the appropriate available educational resources for the given learning activities, based on metadata descriptions. Nevertheless, this requires access to enhanced LORs that store metadata descriptions, which capture the context of educational resources' intended use. This requirement is essential for reducing costs and efforts in selecting educational resources.

3.4.2 Delivering Context-Aware Learning Designs

The design requirements of a mobile delivery tool for context-aware learning designs (compatible with the IMS LD specification) with content adaptation rules for educational resources filtering and transformation could be summarized as follows:

- Requirement 1: The tool should be able to automatically detect learner's mobile context dimensions, namely, learner's temporal information, place, device, time, and physical conditions, according to the learner's situation, and it should be able also to allow the learner to insert contextual information that is not possible to be detected automatically. This is an essential requirement so that the learner's current situation can be fully detected and recorded by the tool.
- Requirement 2: The tool should be able to import context-aware learning designs compatible with IMS LD, and this process should be facilitated by providing the learner access to learning design repositories (Sampson et al. 2011), where the learner can search and find appropriate learning designs according to his/her needs and preferences. This requirement makes the process of selecting learning designs more flexible for the end users of the tool.
- Requirement 3: The tool should be able to handle the adaptation rules of the delivered context-aware learning design and match them with the values of learner's mobile context dimensions automatically detected or provided by the learner so as to deliver adapted educational resources according to the learner's available mobile device. This is an important requirement for providing the learners with valid adapted mobile educational content.
- Requirement 4: The tool should be client-side, so it can be installed on the mobile device, and no Internet connection should be required during the execution of learning activities. Internet connection should be required only during real-time content transformation process, when the tool should communicate with the transcoding server. This requirement is important because mobile devices are not

constantly connected to the Internet and the learner should be able to execute the learning activities even if he/she is not connected to the Internet.

- Requirement 5: The learner should be able to view the graphical structure of the learning activities that a learning design incorporates and navigate to these learning activities. This requirement makes navigation to learning activities more usable for end users.

3.5 Conclusions and Future Work

In this book chapter, we discuss the issue of mobile educational content adaptation by exploiting a learner's mobile context dimensions, namely, learner's temporal information, place, device, time, and physical conditions, and we proposed a mechanism and a corresponding process for context-aware educational content adaptation. We argue that the formal description with a notation language of the adaptation engine of our mobile educational content adaptation mechanism could be a possible solution for overcoming identified limitations of existing adaptations engines of mobile educational content adaptation mechanisms. The implementation of the proposed solution is achieved by adopting IMS LD specification so as to model in a machine-readable format the adaptation rules of the adaptation engine of our proposed mechanism. This design decision provides us the capability to extend traditional mobile educational content adaptation process (performed in run time) to two levels, namely, at the design time and at the run time, with clear benefits in reducing the time of delivering adapted mobile educational content to learner's mobile device. Finally, we present design requirements for a set of tools that enable authoring and delivering of context-aware learning designs with content adaptation features.

Nevertheless, it should be mentioned that the adaptation engine of our proposed mechanism (despite the fact that it is flexible enough for defining new adaptation rules) might need an important number of adaptation rules so as to cover all possible instances of a learner's mobile context dimensions. This could be a possible limitation of the proposed adaptation engine, which could be overcome by considering the use of decision-based adaptation algorithms (Sampson and Karampiperis 2012). Finally, other future work includes (a) the prototype implementation of the tools that were designed in this book chapter; (b) the interconnection of the proposed authoring tool with enhanced LORs that store metadata descriptions, which capture the context of educational resources' intended use towards providing appropriate recommendations to the author during the process of authoring context-aware learning designs; and (c) the further extension of our adaptation approach towards adapting learning activities (not only educational resources) taking into account a learner's mobile context dimensions.

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Chapter 4
Student-Centered Multi-agent Model for Adaptive Virtual Course Development and Learning Object Selection

Demetrio Arturo Ovalle, Francisco Javier Arias, and Julian Moreno

4.1 Introduction

In the last decades, one of the main contributions that has occurred to virtual course development is the adaptation capacity. The main idea behind this contribution is that learners are provided with enriched learning experiences considering their individual needs and characteristics.

Diverse kinds of adaptation have been mainly used on the following issues: instructional plans, knowledge level assessments, and presentation of educational contents (Brusilovsky et al. 2004). This chapter is focused on design and construction of virtual courses using adaptive characteristics, through the integration of artificial intelligence—AI techniques such as multi-agent systems—MASs (Weiss 2007; Wooldridge 2010) and intelligent planning (Duque 2006, 2009). It is important to highlight that the virtual course adaptation will be emphasized in both the instructional planning and the student-centered intelligent selection of learning objects.

The rest of the document is organized as follows: In Sect. 4.2, the theoretical framework is presented, and related works are described and analyzed in Sect. 4.3. In Sect. 4.4, the proposed architecture for adaptive virtual course construction is shown. In Sect. 4.5, a multi-agent model related to the proposed architecture is offered, and in Sect. 4.6, some results obtained from the validation of the proposed model are discussed. Finally, Sect. 4.7 displays the main conclusions and the future work.

D.A. Ovalle (✉) • F.J. Arias • J. Moreno
Universidad Nacional de Colombia, Medellín, Colombia
e-mail: dovalle@perseus.unalmed.edu.co; fjarias@uchicago.edu; jmoreno1@unal.edu.co

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4.2 Theoretical Framework

Adaptive virtual courses—AVC—are computational systems designed to intelligently support teaching–learning processes focused on the student–system interaction and considering the execution of several customized educational tasks (Brusilovsky and Peylo 2003). Most AVC makes use of the following three components: domain model, student model, and pedagogical model. Additionally, learning objects—LOs (Wiley 2000)—that support the AVC can be defined as any educational resource with a pedagogical intention, composed of one or several educational contents, describing themselves through metadata. Thus, LOs can be used within a teaching–learning virtual platform and have the very relevant characteristic of being reusable.

Instructional planning is the AVC's main component whose role is to continuously determine the sequence (learning plan) of consistent and coherent pedagogical activities (Duque and Ovalle 2011). In addition, the goal of the instructional planning is to optimize the learning process for each of the students, allowing them to reach their instructional goals (IGs) generated dynamically during a virtual learning session (Duque 2006, 2009; Arias 2010).

One of the most frequent problems remaining when pedagogical developers are working with LOs (Wiley 2000) is the difficulty of establishing which LOs are the most appropriate for a specific instruction definition. In the AVC, this difficulty also appears; thus, it is important to consider two issues of high relevance: the personal characteristics of each student and the specific features of the selected LO.

MASs have emerged from the distributed AI field and are focused on the intelligent coordination among a collection of smart autonomous or nearly autonomous entities called "agents" (Weiss 2007; Wooldridge 2010). Software agents can execute within any context or environment but also can communicate to each other and coordinate their knowledge, goals, plans, etc., for decision-making purposes or for jointly solving complex problems.

4.3 Related Works

Jiménez (2006) proposes an instructional planning model based on case-based reasoning and pedagogical MAS. The model allows the system to adapt the instruction to the specific needs of each student, providing flexibility and autonomy to the teaching–learning educational environment according to the software agents' characteristics. However, this approach does not consider student-centered adaptive LOs selection.

Duque (2006), on the other hand, exhibits a model for the generation of virtual courses that adapts itself to the own characteristics of each student. The model is oriented by IGs that are expected to be fulfilled by the student when he/she interacts with the virtual course. For doing so, this system applies AI planning techniques. Peña et al. (2002) propose an adaptive intelligent tutoring system (ITS) based on learning styles without considering AI planning techniques and LOs selection. Other works have taken advantage of artificial intelligence planning techniques, in particular the HTN (hierarchical task network) planner for composition courses (Ullrich and Melis 2009).

Morales et al. (2007) presents a way to evaluate LOs from a technical and pedagogical perspective using an assessment range that will be included within their metadata. The purpose is that such assessment values can be accessed in an automatic way through intelligent agents using the LO's quality criterion for their selection. López (2005) defines a conceptual model that structures LO repositories in such a way that the interoperability among different repositories along with the e-learning environment's components can be attained.

4.4 Architecture Proposed

We propose a hybrid architecture for the design and development of AVC, based on the following AI research axes: the instructional planning, the intelligent student-centered LOs selection, and the MAS approach that provides an AVC's generic architecture. The main components of an AVC's generic architecture are the domain model, the student model, and the pedagogical model.

In the domain model, the structure of the virtual course and its related knowledge base are stored. It is important to note that in this model, the use of a specific structure of courses is not mandatory, but it is recommended to develop a pedagogical structure that be composed of the following main elements (Arias 2010): general course, learning basic units (LBUs), topics, IGs, IG's pre-requirements, pedagogical activities, and LOs.

The student model contains the body of knowledge that will characterize the student and is represented through different perspectives such as the following: the student's most relevant psychosociological features that affect his/her learning processes, the knowledge level that he/she has on the virtual topic's domain, and the skills and minimum abilities that he/she must have to perform a task. In addition, this model must be able to gather the evolutionary behavior of the student during different learning sessions and to be able to model the student's mental state. That means both "What does he/she know about a topic? and What does he/she *not know*?" and starting from this initial state allowing the system to adapt its behavior on the basis of his/her answers. According to Jiménez (2006), this model comprises the following elements: student's already reached IG, cognitive profile, contextual characteristics, learning styles, and psychosociological profile.

The pedagogical model acts as a tutor or teacher, and this is the reason why this model is in charge of carrying out instructional planning strategies as well as selection of LOs in a customized way based on the student's characteristics.

4.4.1 Instruction Planning Selection

The instructional planning strategy is based on the AVC's generic architecture and on some AI planning basic concepts; thus, it may be described as follows (see Fig. 4.1):

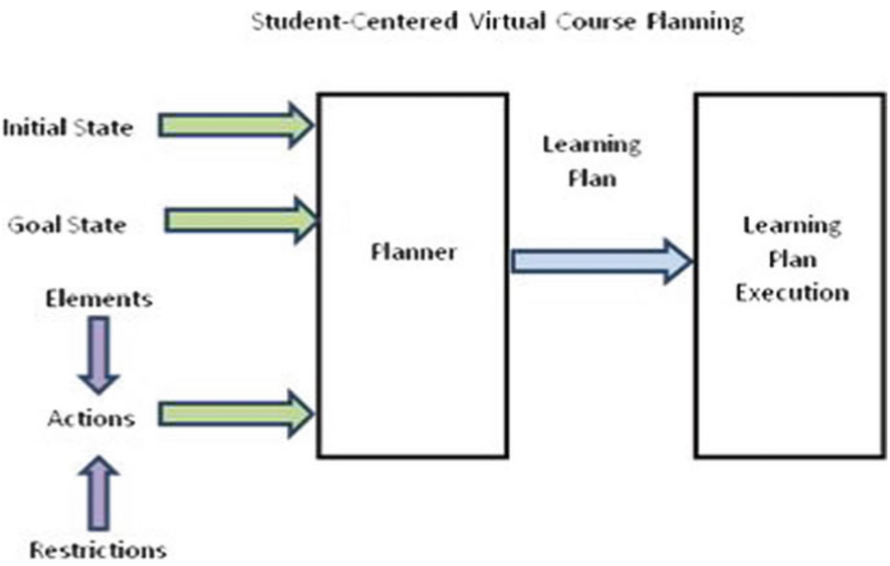

Fig. 4.1 Basic process of AVC learning-planning technique

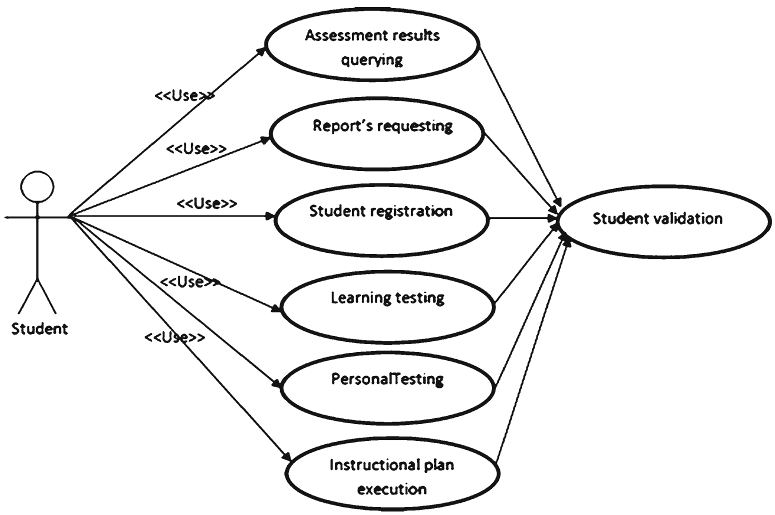

Fig. 4.2 Student use case

- Problem: Formulation that expresses the knowledge associated with topics of a specific course that the students try to acquire.
- Initial State: The student has basic concepts in the field, which will help him/her to acquire new concepts.
- Final State: The student has acquired new knowledge and thus has attained one or several IGs.

- Actions or Activities: They are specified by the teachers while they build the corresponding virtual course, and they must be associated to an IG.
- Elements (LOs): They are related to one LO or a group of LOs that will be used when a pedagogical activity is performed. Each LO must contain specific metadata allowing its selection in adaptive way.
- Restrictions: They can be established at two levels; the first level is related to the structure of the virtual course and is known as "pre-requirements" that indicate what IG must be attained in order to reach another IG. Given the subdivision of the course structure in the four related components—general course, LBUs, topics, and learning activities—when a pre-requirement is defined for an IG, such a pre-requirement should also be applied to a topic, to a LBU, and to the entire course.

The second level concerns the instruction of the students and can be named as goals by the student. The student information elements with adaptive purposes that the system will store are the following: data and personal characteristics, academic profile, personal profile, contextual characteristics, learning performance, and tasks' knowledge level. In order to develop the planning strategy, the following stages should be carried out:

1. Teachers must structure their virtual courses according to the elements specified within the domain model by using requirements and pre-requirements that are associated to each IG. It is important to remark that at least one IG without pre-requirements must exist in order that the system can plan the virtual course's initial activities.
2. When a student enters to the course, the system must verify, using the pre-requirements, which IGs are available in such a way that a list of topics is generated.
3. Once the student selects a topic, the system thus generates an adapted instructional plan tailored to the student's knowledge level and to her/his preferences. This learning plan is composed of one or several IGs that the student should attain when performing one or several learning activities.
4. The system guides the student through the instructional plan's activities. In addition, it is important to note that each activity can be custom-made by the student using suggestions given by the multi-agent system concerning one or several LOs. This selection of LOs is needed to be done by the system, taking into account the student's learning styles previously matched with the metadata that describe them.
5. When the student has performed all the activities associated with the instructional plan, it is considered necessary to verify if the student actually learned the concepts related to the selected topics; hence, a knowledge assessment is launched by the system for learning validation purposes.
6. The system is in charge of updating the student's knowledge level according to the achieved results (IGs attained by the student) based on the previous instructional plan assessment. It is important to underline that once the student's knowledge level is updated, then new virtual course topics are activated to be pursued.

4.4.2 *Learning Object Selection Strategy*

Concerning the LO selection strategy, two cognitive student characteristics were considered: the learning styles, acquired through the Felder and Silverman test (Felder and Spurlin 2005), and the dominant cerebral hemisphere, acquired through the triadic quotient detector test—TQDT (De Gregori 1999). Even if several authors consider a lot of more characteristics (Das et al. 2010; Zervas et al. 2011), we focused in those two considering their robustness, i.e., the quantity of studies where they were successfully implemented (Brown et al. 2009), and the easiness for their measurement.

In order to perform the LO selection according to the students' profiles within the AVC, the model must perform the following steps:

1. The system first captures the students' learning styles using the Felder and Silverman test that is composed of 44 questions in order to classify students' learning abilities with respect to the following four dichotomies: [active, reflective], [sensing, intuitive], [visual, verbal], and [sequential, global], having 11 questions for each dichotomy. After applying this learning test, a given student could have, for instance, the following results: {[7, 4], [3, 8], [9, 2], [5, 6]}, meaning that the student is 63% more active than reflective (37%), 73% more intuitive than sensing (27%), 82% more visual than verbal (18%), and 55% more global than sequential (45%).
2. The students' dominant cerebral hemispheres through application of the TQDT are then acquired by the system. According to De Gregori (1999), the brain and its three main processes—logic-scientific-rational side (left hemisphere), intuitive-spiritual-mystic-proactive and visionary side (right hemisphere), and central-organizational-administrative-productive side (central hemisphere)—must be used and developed in such a way that an individual be able to take advantage and seize on all of his brain capacity. This test is composed of 27 questions in which 9 are associated to each one of the hemispheres (left, right, and central). Each question is graded within the range [1, 5], meaning that each hemisphere can obtain a minimum total value of 9 and a maximum of 45. After applying this test, a given student could have, for instance, the following results: [39, 12, 23], meaning that the student is an individual 87% logic-scientific-rational, 27% intuitive-spiritual-mystic-proactive, and 51% central-organizational-administrative-productive.
3. The system continues by selecting the best kind of resources (e.g., simulation, graphic, experiment, document) as well as the best kind of suitable educational resource formats (e.g., avi, ppt, swf, jpg, wav) that best match the obtained values for the student's learning styles and cerebral hemisphere.
4. A list with the "best? LO resources types" and the "best? LO formats" is generated for a given student (see Table 4.1) using student's test results and LO metadata specified under IEEE LOM standard (IEEE 2005) inside the following categories: general description (name, content description, keywords, etc.), educational (interactivity style: active, sensitive, reflective, visual, verbal, etc.), and technical (format and size: swf, avi, doc, txt, jpg, ppt, etc.). Thus, while active students prefer using LO resources like simulations, experiments, problem statements, among others, reflective ones prefer using self-assessment, reflective and analytical texts, among others (see Table 4.1).

Table 4.1 LO resource types and formats best fitting for different kinds of student's learning styles

Learning style	Resource type	Format
Active	Simulation, experiment, problem statement	swf, exe
Reflective	Self-assessment, analytical text	doc, txt, pdf
Sensing	Experiment, diagram	swf, avi, mpg
Intuitive	Lecture, questionnaire	doc, txt, ppt, xls
Visual	Figure, graph, diagram	jpg, png, gif, tif, bmp
Verbal	Narrative text, essay	doc, txt, pdf
Sequential	Index, guide, graph, diagram	ppt, pdf
Global	Slide, narrative text	jpg, doc, txt, ppt

5. The system continues with the generation of a list that represents all the possible combinations between individual students' tables "top recommended of LO resource types" and "top recommended of LO resource formats."
6. When the student is performing the instructional plan, previous to performing an activity, the system should check which LO must be selected to correspond with the most relevant characteristics according to the table that represents all the possible combinations between an individual student's tables "top recommended of resources" and "top recommended of resource formats."

4.5 Multi-agent Model for the Proposed Architecture

The multi-agent model proposed is described based on the MAS-CommonKADS methodology (Iglesias 1999). This methodology is mainly composed of the following three phases: conceptualization, design, and analysis.

4.5.1 Conceptualization Phase

In the conceptualization phase, the problem to be solved is defined and the scope of the model is established. Also, the entities that compose the AVC are identified, and in general, the global operation of the system is established. From the basic architecture of the proposed AVC, the following actors were identified:

- Teachers: Their main role will be creating and structuring virtual courses and continuously monitoring the student performance.
- Students: Their main purpose in the system is acquiring knowledge about a course, through the use and application of instructional planning generated by the system and adapted to their academic level and learning styles. Figure 4.3 presents an example of a use case for the actor "student," using the notation proposed by Jacobson in Jacobson et al. (2000).

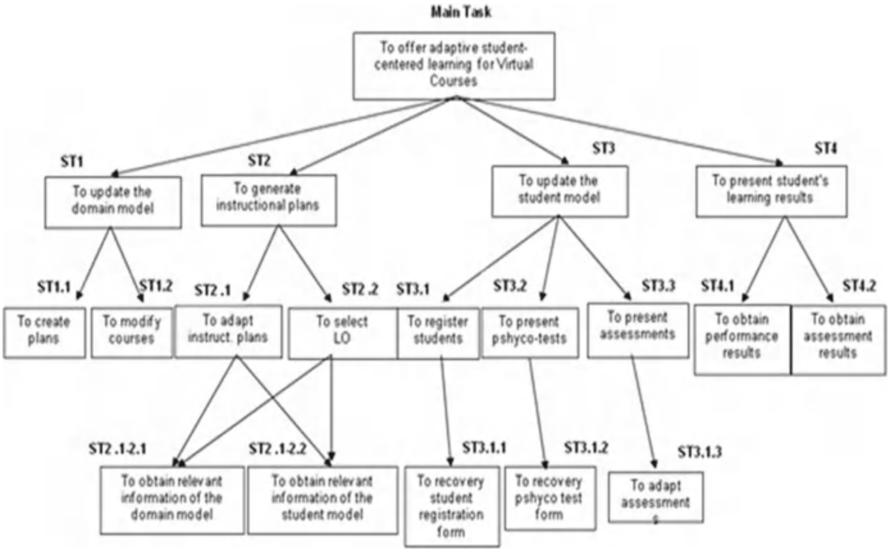

Fig. 4.3 Task model represented by a hierarchical tree

- Planner: His role is to adapt instructional plans to students in such a way that the student be guided by the system through a teaching–learning process in the same way as it could be performed by a real teacher.

4.5.2 Analysis Phase

In the analysis phase, the MAS-CommonKADS methodology proposes for the following models: agent, organization, task, experience (or knowledge), communication, and coordination.

In the agent model, every agent's characteristics are specified: reasoning skills, abilities, services to offer, sensors, effectors, agent groups to whom it belongs, and agent's kind. An agent can be a human, software, or any entity capable of using an agent communication language (ACL). The description of those features is carried out by using an agent template.

The organization model allows analyzing the human organization in which the multi-agent system will be developed and also describes the software agent's organization and its connections with the environment.

The task model describes the tasks that pedagogical agents are capable of performing. A task can be defined as the set of activities that have to be developed to achieve a specific goal in a given domain. For each task, the following items must be specified: name, goal, inputs, outputs, subtasks, and models. Figure 4.3 describes each of the tasks that were identified for the learning system. It should be noted that a main task is composed in turn of four subtasks

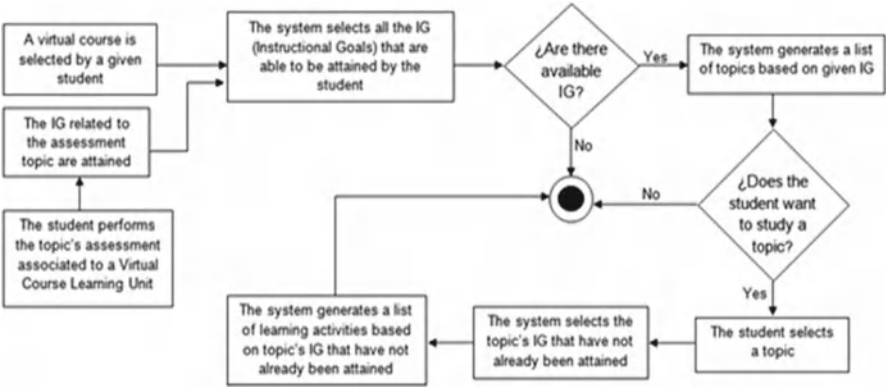

Fig. 4.4 Reasoning mechanism flowchart

known as the following: main task provides individualized learning for a specific AVC; ST1 (subtask 1) is in charge of updating the domain model; TS2 (subtask 2), whose role consists in generating instructional plans; ST3 (subtask 3) is in charge of updating the student's model; ST4 (subtask 4) presents student's learning process results.

The expertise model (or knowledge model) firstly has a main role to identify the most appropriate ontologies that are needed to be used within the problem's domain; in this way handled concepts in the system are clearly recognized.

Another relevant feature of this model concerns the identification of reasoning mechanisms that should be developed within the system provided through intelligent skills of software agents. It is important to highlight that two kinds of ontologies focused on the virtual course's information management were handled in this problem. Figure 4.4 shows, for instance, the flowchart corresponding to the reasoning mechanism employed by ST2.1.

The coordination and communication model is designed with the aim of modeling the agent-to-agent and human-to-agent interaction. Since this model presents a very technical approach supported by the agent framework development tool, it will not be described here. More details of this model can be found in Arias (2010).

4.5.3 Design Phase

Finally, the design phase concerns the deployment of components that the system will handle and additionally the definition of computational tools that will be used to carry out the system implementation. Figure 4.5 shows the deployment diagram which corresponds to one of the artifacts used in this phase where the hardware and software architecture must be defined.

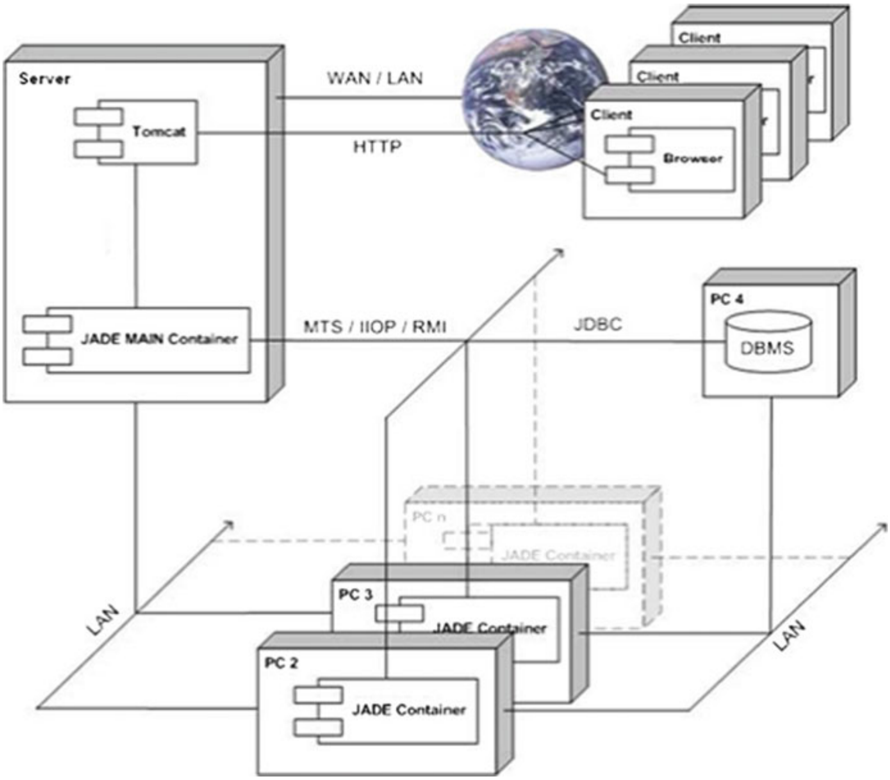

Fig. 4.5 Deployment diagram of CIA multi-agent system

4.6 Prototype Implementation

The platform CIA (Spanish acronym for Adaptive Intelligent Virtual Courses) is the computational prototype that validates the proposed model and was implemented using the platform JADE (Java Agent Development Framework; Bellifemine et al. 2005), which is distributed on a LAN network. A Tomcat Web server was housed in a computer located on one of the LAN (Local Area Network)'s nodes. In this site, they are located at the JADE's main container which not only provided FIPA (Foundation for Intelligent Physical Agents) compliant JADE agents, such as AMS (Agent Management System), DF (Directory Facilitator), and RMA (Remote Management Agent), but also some agents of the system, such as planner and evaluator.

On the other hand, there are additional containers distributed on different computers located in other nodes of the same LAN network where the other agents of the system such as students and teachers were situated. When a student is registered in the system, the interface agent displays to him/her a form to be filled with personal information and two tests (Felder and Silverman test and TQDT-Triadic

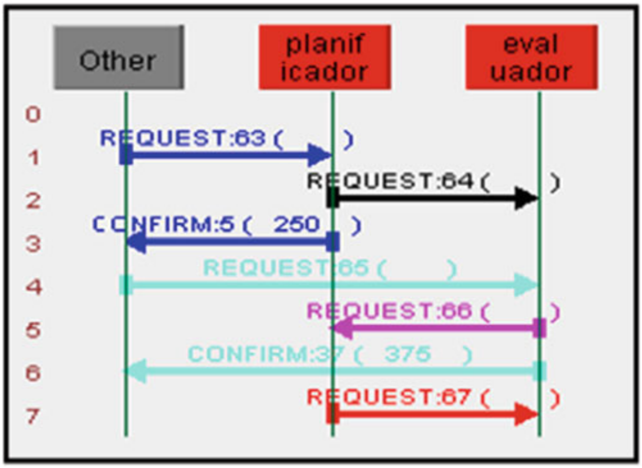

Fig. 4.6 Agent's interaction sequence diagram

Quotient Detector test) to be performed by the student in order to capture his/her personal data and learning styles which are relevant to the learning planning and the LO selection tasks. It is important to underline that the interface agent acts as an intermediary between human and software agents. Figure 4.6 shows through a sequence diagram generated by the JADE's sniffer agent (Bellifemine et al. 2005), the communication protocol established among the interface agent (represented in Fig. 4.6 as *other*), the planner agent, and the evaluator agent.

The specific learning study case that was considered for this research work is described as follows:

1. A student, through the interface agent, sends a planning request (REQUEST:63) after selecting a virtual course topic.
2. The planner agent receives the request sent by the interface agent and thus generates an adaptive instructional plan according to the planning strategy presented above and asks the evaluator agent (REQUEST 64) on the assessment planning, and a response is sent to the interface agent about its planning request (CONFIRM 5).
3. While the student runs his/her individual instructional plan, the most appropriate LOs are selected according to the student's personal information provided by the system and the outcome from the LO selection process carried out by the CIA learning strategy (see Table 4.1).
4. When the student has finished studying all the activities associated with the instructional plan, a knowledge assessment test is then generated and deployed by the evaluator agent in order to update the learning level record of the student.

Finally, since CIA is an initial multi-agent system implementation for adaptive course planning, the aspects about security are not yet completely considered and will be taken into account in future versions. However, it is important to remark that the personal student's data are only handled by professors and system managers without any possible access of other persons or students.

4.7 Conclusions and Future Work

This chapter showed the use of various AI techniques such as AI planning and MAS for the development of student-centered adaptive virtual course development which carry out learning planning and individual LOs selection in an intelligent way, taking into account the students' knowledge level, their learning styles, and their most used brain hemisphere. The process of LO selection which involves the adaptive selection of students' most appropriate resource type (e.g., simulation, graph, experiment, document) and resource format (e.g., avi, ppt, swf, jpg, wav) uses specific learning style through the application of the Felder and Silverman test and TQDT. The MAS was successfully used to integrate the strategies of learning planning and LOs selection and to support the AVC construction in a modular, distributed, deliberative, proactive, and cooperative way.

As a future work, it will be envisaged to enlarge this student-centered learning model in such a way that it could provide LO recovery and recommendations from local and remote LO repositories (e.g., MERLOT, CeLeBraTe, CAREO) or through LO repository federations (e.g., FEB, aDORE, ARIADNE), in such a way that the system can automatically get learning resources and easily add those to a specific virtual course under the teacher supervision.

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Part II
Mobile and Ubiquitous Informal and Formal Learning Environments

Chapter 5
Integrated Platform for Mobile Learning

Elissaveta Gourova, Asya Asenova, and Pavlin Dulev

5.1 Introduction

Since the invention of the telephone more than a century ago, the information and communication technologies (ICT) have experienced enormous changes and have influenced the work and life of people all over the world. Today, ICTs provide opportunities to end users to access information and knowledge everywhere, at any time, using a large variety of devices. This has created the phenomenon of "ubiquitous computing." The rapid changes of technologies, business models, and processes, and more generally in economy and society, have faced people with the need to be more flexible, to learn and adapt continuously to contemporary trends. Subsequently, lifelong learning has become a permanent characteristic of present employees faced with the need to enhance their knowledge and skills beyond the formal education obtained in schools, colleges, or universities (Gourova et al. 2009). In addition to traditional educational institutions (e.g., schools, colleges, universities), several new actors have emerged to respond to the demand for lifelong learning and to provide new educational services such as certification programs, training courses, and distance education.

Traditional educational institutions have faced several challenges due to technology developments, globalization, and the increased competition on the educational market. They have been forced to introduce deep changes in educational programs, at organizational, technological, and methodological levels. Nowadays, computer-savvy generation have other demands for education and training. They grow with technologies around, and it is not surprising that traditional educational methodologies (requiring classroom presence, using printed materials for learning and assessment, etc.) become obsolete. At the same time, the emergence of Web 2.0 technologies has caused the uptake of collective intelligence and collaboration, which could essentially influence education and

E. Gourova (✉) • A. Asenova • P. Dulev
Sofia University, Sofia, Bulgaria
e-mail: elis@fmi.uni-sofia.bg; asya_asenova@yahoo.com; pavlin_dulev@yahoo.com

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learning outcomes. The University 2.0 model has emerged from the social computing phenomenon based on Web 2.0 (Nikolov 2009).

The demand for lifelong learning and, in particular, for educational services at a distance, is behind several phases in learning content provision—using initially paper form, later broadcasting educational programs on radio or television, or disseminating learning materials on CD/DVD (Vinu et al. 2011). Today, several researchers consider that the technological trends are behind a new change—from e-learning to mobile learning (m-learning) by using mobile devices for accessing learning content and services everywhere, at anytime (Korucu et al. 2011; Vinu et al. 2011).

Mobile learning or m-learning is a new trend in the provision of educational services at a distance. The integration and usage of mobile devices allows education at anytime and anywhere. Initially, m-learning was considered to be a type of e-learning provided at mobile devices instead of desktop computers (Karadeniz 2009). However, the rapid developments in wireless technologies and mobile devices, as well as their mass usage, raised the need for development of specific methodologies and standards for m-learning (Georgieva et al. 2005). Thus, m-learning started to be separated from e-learning and considered as a new educational approach with its own specificity. M-learning faced researchers and practitioners with several questions that need to be resolved. Some challenges are linked to the development of m-learning standards as m-learning systems do not support e-learning specifications (Georgieva et al. 2005). Another challenge is to ensure that the middleware provides interoperability of different devices and applications, system scalability, extensibility, and reusability, as well as guarantees security and privacy (Martin et al. 2011). In addition, there is a need for appropriate management of courses, preparation of self-study educational materials, and design of educational modules, which are accessible at various devices (Dulev 2011).

The main research questions in this paper are the following: which devices are more suitable for m-learning, how to design m-learning courses in Sofia University (SU), what kind of content is more suitable for m-learning, and how to integrate m-learning in present education.

The first chapter provides an overview on the state of the art, focusing, first, on recent wireless technology trends and mobile devices constraints. Second, the authors make a short overview of the m-learning concept as discussed by scholars and present some approaches for m-learning systems design. The utilization of mobile devices and, especially, tablets in m-learning is further discussed in this chapter. Some advantages and limitations of present devices are outlined as well. The second chapter considers how to use tablets in education and provides a new concept for m-learning design: how to organize m-learning, which learning styles are appropriate with a tablet, and how to structure a course for m-learning. A concept for introduction of video lectures is considered by the authors, and the results of small-scale surveys are presented, highlighting students' attitudes for m-learning and the appropriateness of tablets for different types of content used in education. The third chapter is devoted to a concept for integration of m-learning in present education at SU. The authors consider the development of a platform, providing opportunities for text, audio, and video educational materials to be accessed by mobile devices.

5.2 Mobile Learning Trends

5.2.1 Development of Technologies

Telecommunications have undergone enormous changes within the last 150 years—beginning with the invention of the telephone and, going over fixed, wireless and satellite communications. The fast ICT penetration worldwide has created the phenomenon of "ubiquitous computing"—whereas information and knowledge could be accessed regardless of time and space, using a big variety of smart devices. The enormous changes in transmission technologies, hardware equipment, and software development facilitated the uptake of mobile communications worldwide.

Through fixed, wireless, or satellite systems, people could communicate with each other, search and exchange information at anytime and anywhere. The wireless communication technologies, in particular, have experienced large expansion worldwide, first, due to the greater network access flexibility, and second, due to the reduced infrastructure investments and the ability to transmit data, voice, and video with a proper service quality (Gourov 2011). In Europe, for example, the adoption of a common standard for mobile communications—Global System for Mobile Communications (GSM) and the available coverage (more than 90% all around Europe)—have facilitated users to switch between providers and use their mobiles at any time and at any place.

Irrespective of the devices, users could connect to a personal area network (PAN), local area network (LAN), or a wide area network (WAN) via various wireless communication technologies (Bluetooth, Wireless Fidelity (WiFi), Universal Mobile Telecommunications System (UMTS), third-generation (3G), etc.) (Gourov 2011; Vinu et al. 2011; Saenz et al. 2009). For example, the WLAN 802.11 technology is among the most widely deployed wireless networks and can be encountered everywhere, e.g., in places such as homes, offices, universities, hospitals, and schools. The Worldwide Interoperability for Microwave Access (WiMAX) has quality of service of cellular networks and provides broadband wireless services up to 50 km for fixed stations and 15 km for mobile stations, thus making it a competitor to the 3G mobile standards (Gourov 2011). At the same time, the Wireless Application Protocol (WAP), supported by a large number of suppliers, enables access to the Internet from mobile devices. Another technology that enables high-speed wireless Internet is general packet radio service (GPRS) operated all over the world (Georgiev et al. 2004; Saenz et al. 2009).

Some data show that already in 2008, the penetration of mobile devices became much higher than the penetration of computers in the world (Niazi and Mahmoud 2008). Presently, mobile devices facilitate the professional and private life of users. They provide many opportunities to their users—to interact with others over the phone or the Internet; to browse online content; to download text, images, or movies; to entertain with games, books, music, or films; to get navigation assistance; etc. Thus, mobile devices become essential elements of their everyday life and work and are a proper tool to be utilized also in education. A factor supporting the introduction of m-learning is the fact that young people are widely using them.

There is a large variety of mobile devices which could be used in education. Some of them have comparable performance to personal computers (Georgiev et al. 2004):

- NoteBook computers: in addition to the performance capabilities of desktop computers, they support wireless communications and have also smaller size.
- Tablet PCs: have full range of abilities like personal computers.
- Personal digital assistants (PDA): possess significant processor power and have small size.
- Cellular phones: most devices could be used to Internet access and to send and receive the multimedia messages (MMS).
- Smart phones: hybrid devices combining the abilities of cellular phones and PDA, but with smaller size than PDA.

It could be summarized that recent technology trends facilitate the uptake of m-learning and the access to educational content through wireless technologies and devices. The increasing penetration of mobile devices, especially among young people, is further supporting m-learning. However, it is necessary to undertake a careful assessment of the type of device most suitable for the specific educational purposes.

5.2.2 The M-Learning Concept

New technologies enable different educational approaches which coexist and complement each other. As shown on Fig. 5.1, e-learning could be provided on desktop computers (computer-based learning—CBL), online (Internet-based learning—IBL, Web-based learning—WBL), or using mobile devices (m-learning). Karadeniz (2009, p. 359) considers that a variety of methods could be applied in order to facilitate learning—"distance learning can use face-to-face learning environments to help learners to acquire skills, construct knowledge through discussions and real-life situations, and provide social learning context. Textbooks, journals or other printed media can also help learners to study in their own time and place." While new technologies provide great opportunities for ubiquitous computing and facilitate e-learning and m-learning, there is obvious still space for traditional face-to-face learning or its combination with e-learning (defined as blended learning or b-learning).

The mass usage of wireless communications facilitates the provision of educational content to people who could not find time to attend regular courses or who are far away from the place where the courses are delivered. The concept of m-learning extends the opportunities provided by e-learning by taking advantage of recent developments of mobile devices and pervasive computing (Gourova et al. 2011). As pointed out by Ebner et al. (2009, p. 34), "the increased availability of free wireless network access points, affect the way that end users interact with ubiquitous devices, extending traditional e-Learning into a new phenomenon named: Ubiquitous Learning," which is defined as a "function of u-Environment, u-Contents, u-Behavior, u-Interface, u-Service."

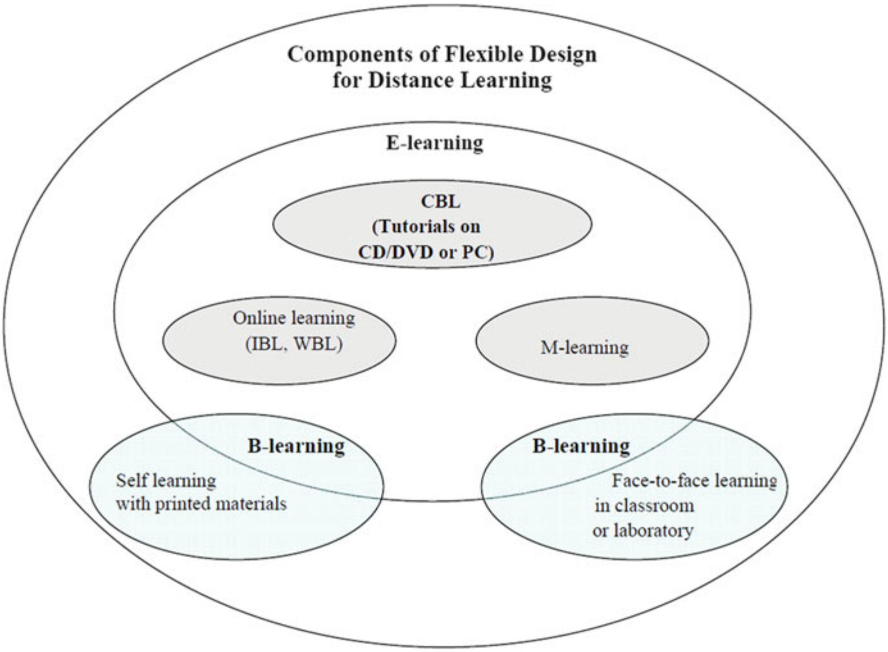

Fig. 5.1 Distance learning components (Karadeniz 2009)

According to Vinu et al. (2011), m-learning "happens when the learner is not at a fixed, predetermined location, or … when the learner takes advantage of the learning opportunities offered by mobile technologies." M-learning could provide students with a smart learning environment but also could navigate them in the campus when they enter for first time. Sensors and location services (global positioning system (GPS), radio frequency identification (RFID), etc.) especially facilitate such navigation, as well as the opportunities of smart devices to display images, text, and sound (Vinu et al. 2011). M-learning ensures synchronous and asynchronous communications of students and provides them access to both educational and administrative services. M-learning methods could be also utilized for building a virtual classroom (Vinu et al. 2011) or for remote laboratory experiments (Cmuk 2007).

A comparison with e-learning in (Korucu et al. 2011, p. 1926) suggests the following advantages of m-learning:

- Lifelong learning
- Learning inadvertently
- Learning in the time of need
- Learning independent of time and location
- Learning adjusted according to location and circumstances

Table 5.1 Differences between e-learning and m-learning, adapted (Korucu et al. 2011)

E-learning	M-learning
Students interaction	
Audio-teleconference common	Audio- and video-teleconference possible
e-mail-to-e-mail	24/7 instantaneous
Private location	No geographic boundaries
Travel time to reach Internet sites	No travel time since wireless connectivity
Dedicated time for group meetings	Flexible timings for group meetings
Poor communication due to group consciousness	Rich communication due to one-to-one communication, reduced inhibitions
Environment and methods for evaluation	
Dedicated time	24/7 instantaneous
Restricted amount of time	Any amount of time possible
Standard test	Individualized tests
Usually delayed feedback	Instant feedback possible
Fixed-length tests	Flexiblelength/number of questions

At the same time, other differences are linked to the environment and methods for students' evaluation and students' interactions (Table 5.1). It is obvious that m-learning provides greater flexibility for students to be examined or to interact at any time and at any place, as well as the tests could be individual in m-learning and get a response immediately.

5.2.3 Usage of Devices for M-Learning

Many researchers have studied the impact of m-learning and its appreciation by end users. It is interesting to note that introducing mobile devices in school could bridge the digital divide and contribute to social equity. A study on using tablets in Spanish schools shows that these devices contribute to reduction of inequalities in pupils' academic performance, in terms of gender as well as birthplace and the mother's level of education (Ferrer et al. 2011). The results suggest that using tablets in education reduces the difference among students due to their social status and facilitates the performance of those students who have the worst academic records. As the authors point out, the students with greatest benefits were those who were coming from families with more disadvantaged socioeconomic and cultural environments (Ferrer et al. 2011).

As Cavus (2011) points out, it is important for students to collaborate in the learning process, and the mobile devices provide them opportunities to communicate via e-mail, Multimedia Messaging Service (MMS), videoconference, etc. The study shows that the availability of different learning tools increases the motivation of students during the lectures, as well as to achieve better scores. The flexibility and the accessibility of the learning materials at anytime and anywhere are considered by the students as another advantage of m-learning. According to the results, it is clear that students enjoy using mobile devices as a tool in education (Cavus 2011). A study in the UK also reveals some features of pocket PCs appreciated by the students: they prefer to carry these convenient and neat devices instead of the large paper portfolio and edit and extend their records on an ongoing basis. On the other hand, they are not satisfied with the reliability of the devices and the loss of assessment data, the limitations of the software, and the need of more time to enter data (Dearnley et al. 2008).

The satisfaction with a mobile learning system is explored by the FLAGMAN consortium within a Leonardo da Vinci project in Bulgaria and Greece (Georgieva et al. 2011). The purpose of the development of a mobile learning system is to allow creation of training courses for language learning and to facilitate the creation and editing of learning resources suitable for foreign language learning. The system supports five groups of users: administrator, teachers, translators of the interface and system messages, learners, and guests. The system was evaluated using a questionnaire sent to students and teachers pilot using the system. For testing were used the following mobile devices—PDA HP iPAQ hx2790, PDA Dell Axim v51, and smart phone HP iPAQ hw6915. As shown in Table 5.2, the mobile devices used ensure a well-designed user interface to the educational content, easy to use and support different educational resources as well as graphics and sound necessary for foreign language education. Regarding the didactic efficiency, the students consider that m-learning increases the quality of traditional education by making it more enjoyable and interesting. According to the respondents, m-learning provides increased access to education and training; however, the costs for communication with other students and tutors are not acceptable enough (Georgieva et al. 2011).

A more recent study (Alvarez et al. 2011) compares the usage of tablets and laptops in small-group collaborative learning activities. It shows a clear preference of students for tablet and PDA devices instead of laptops. The small size of the screen and the keyboard of tablets or PDA do not cause any inconvenience to students, and the availability of a touchpad is very useful. At the same time, they consider that using of stylus provides an added value with the opportunity to include drawings, and more generally, tablets and PDAs are better for exchange of ideas and group communications than laptops. The overall observation of the authors is that "the tablet type of netbook … promotes fluid physical and verbal interaction between students, stimulating person-to-group dialogue and integrating all group members in group discussions. Using these devices the students were less inhibited about expressing their points of view and in complementary fashion were more willing to listen to others … indicating that tablet-style devices can facilitate a richer face-to-face communication in small group collaboration scenarios" (Alvarez et al. 2011).

It is obvious that some mobile devices (tablets, PDAs) find great appreciation among users. Among their advantages could be summarized:

- Higher students' motivation and better performance
- Small, convenient, easy-to-use devices

Table 5.2 Results on "technical feasibility" (Georgieva et al. 2011)

Statements	Students Athens	Students Dobrich	Students Russe	Lecturers Russe
Graphical user interface is well designed	4.15	4.47	3.73	4.76
Multilingual support is very useful	4.15	4.94	4.28	4.88
Navigation through the mobile learning course was easy	4.15	4.29	3.94	4.72
Learners always know where they are in the course	4.31	4.18	3.57	4.52
Fonts (style, color, saturation) are easy to read	4.31	4.76	4.04	4.48
The courses offer tools (help, resources, glossary, etc.) that support learning	4.31	4.18	3.79	4.80
The course is free from technical problems (hyperlink errors, programming errors, etc.)	4.08	3.53	3.58	4.56
For mobile learning to be effective, it is necessary to use graphics, illustrations, and sound	4.38	4.35	4.28	4.68

- Various communication opportunities
- Flexibility and accessibility
- Support of various educational resources (e.g., text, audio, video)

At the same time, users consider some disadvantages which need careful attention:

- Cost of communications
- Software limitations
- Loss of assessment data
- Increased time to enter data

Surveys among users provide some inputs to m-learning research showing the demand side and the results achieved so far in m-learning pilots. In parallel, other studies consider the devices' functionalities and performance. For example, Saenz et al. (2009) make an analysis of the technology environment for m-learning and assess the mobile devices according to their interface, autonomy, memory capacity, processing power, connectivity, and costs. They consider that the problems of the low internal memory capacity of mobile devices could be generally solved by using external memory—MMC or SD card. In order to reduce connectivity costs, the authors suggest using Infrared, Bluetooth, or WiFi technologies.

Some of the disadvantages of mobile devices include small screen size, limited processing power and memory, low battery life, and reduced input capabilities (Patrichi 2010; Cmuk 2007; Niazi and Mahmoud 2008; Saenz et al. 2009). Other problems are linked to the following (Cmuk 2007; Ebner et al. 2009):

- Low bandwidth: connection limitations (GPRS, UMTS, Bluetooth, WiFi, etc.)
- Software limitations: usage of various programming languages and software versions
- Protocol problems: limitations for usage with existing learning systems
- Application design: limitations due to device characteristics (small screen size and system resources) and the way of users' interaction (need for a simple interface with few images and short pages to avoid scrolling)

For avoiding some of the problems linked to mobile devices, Ebner et al. (2009) investigate the usability of mobile interfaces under three main categories:

- Device usability: here are studied input possibilities (keys, touch screen, pen), display possibilities (e.g., size, color), Web access (WAP, UMTS, WLAN), platform UI style (e.g., Symbian, Android)
- Browser usability: interaction mechanisms (e.g., scroll-and-select, point-click, touch), page rendering (e.g., XHTML, JS, AJAX), caching
- Website usability: structure, content, layout

It could be concluded that by the design of m-learning, it is important to carefully assess which will be the most appropriate device for the specific educational goals and educational content. Different educational subjects require different educational tools—some more appropriate for humanitarian studies and others for engineering.

The choice of a device for m-learning should balance between device performance capabilities (memory, processing power), user-friendliness (input/output, navigation), and interoperability (different e-learning content and applications). Very useful are the guidelines for m-learning courses design suggested by Ebner et al. (2009): according to layout design (flexible, simple, narrow), content quantity (less text), usage of graphics (small), the site structure (flat), and usage of animations (to be avoided).

5.2.4 M-Learning Systems' Design

Various approaches are proposed in the literature for design of m-learning systems (MLS). Parsons and Ryu (2006) study the requirements for m-learning environment. Their main emphasis is on users' learning experiences. The authors consider four learning design requirements (Fig. 5.2)—learning objectives, learning experience, M-learning contexts, and generic mobile design issues. It is obviously essential to consider first which are the educational goals regarding skills building and on this base to decide upon learning activities, content, and methodology to be used. The role of the LMS is to support different roles and facilitate learning activities, interaction, and access to content. On the other hand, it should take advantage of the different media and the opportunities offered by Web 2.0 for social interaction.

COMTEXT framework is a system devoted to the design of ubiquitous learning applications and provides a web-based environment with access to the following tools (Zanela et al. 2009):

- Communication/collaboration: the environment integrates blog, forum, and e-mail tools as well as access to Skype (used for synchronous interaction via chats or direct conversation)
- Multimedia: access to YouTube to download videos
- Repository: online repository of documents (simulations, presentations, demonstrations, etc.)
- Evaluation: ad hoc assessment system
- Location services: location determination by GPS and WiFi
- Context management: association of coordinates with names
- Reminders: reminding users for activities and events

Trifonova and Ronchetti (2004) propose a general architecture for m-learning. The authors broadly group the e-learning functionalities in four categories: access to resources, e-learning services, common services, and presentation. As resources, they consider various learning objects, which should be broken down into small pieces in order to allow modularity and reusability, as well as tests and quizzes for students' assessment or self-assessment. Among the e-learning services considered by Trifonova and Ronchetti (2004) are content management, assessment, knowledge management (KM), and management of learning resources by users. It is interesting to note the inclusion of a KM functionality which is rarely used in universities, however, finds increasingly place in large commercial organizations. The last type

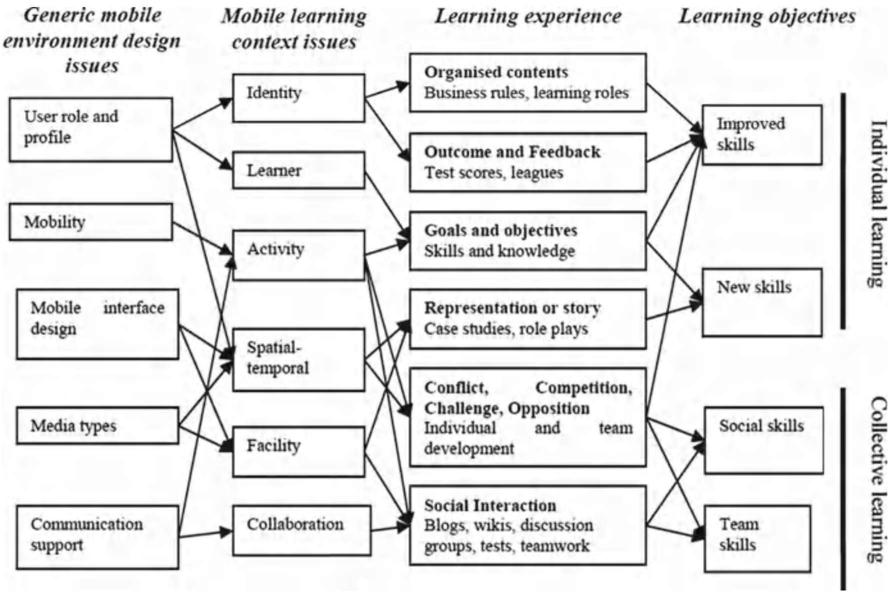

Fig. 5.2 A framework for m-learning design requirements (Parsons and Ryu 2006)

of services comprises communicating tools (various groupware technologies) and management of the access to the system of different users. On this basis, Trifonova and Ronchetti (2004) consider for MLS that it should support all services typical for an e-learning system, as well as to ensure device independency.

Niazi and Mahmoud (2008) consider a management MLS which should use device-independent applications for content delivery and provide opportunities for reusability of the learning objects. The system supports cellular phones, smart phones, PDAs, laptops, personal computers, and tablets. The main units of the system (Fig. 5.3) include the following:

- Mobile learning content management—focused on courses management
- Mobile learning content presentation—for presenting educational materials adaptive to mobile devices
- Context discovery—to support discovering the available courses and quizzes and other context
- Coursework analysis—focused on students' evaluation—their course works, tests, as well as to assign grades, display correct answers and send results to instructors

The research shows that MLS design should be based, first, on the learning goals and should support all activities, teaching methods and media considered appropriate for achieving these goals. The functionalities of the MLS should ensure that the system is easy to use (in terms of access, content management, presentation, and navigation), intuitive, and supports all users' profiles, educational needs, and roles. As a minimum, the MLS should provide modules for the following:

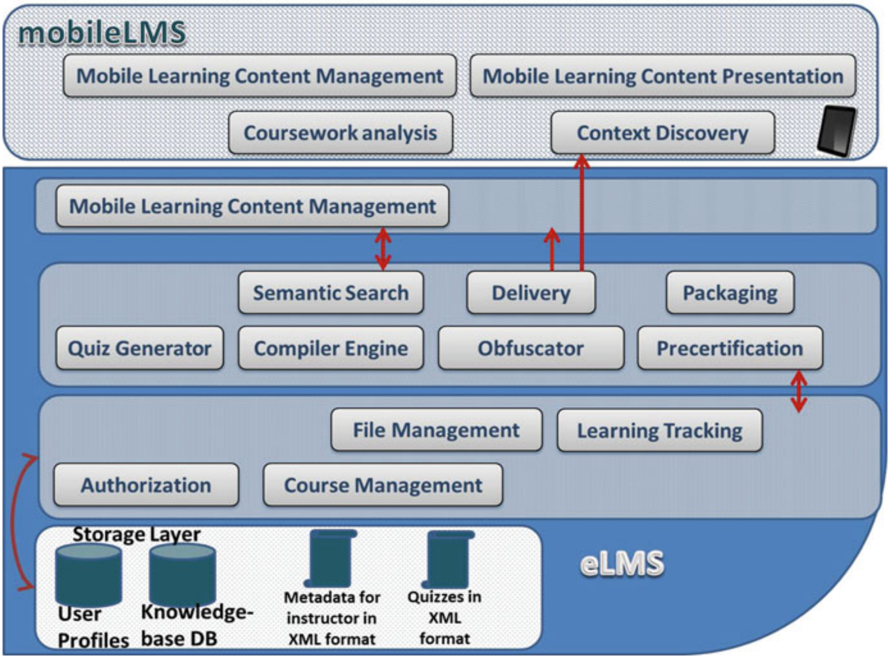

Fig. 5.3 MLS system architecture (Niazi et al. 2008)

- Courses management and users' administration
- Content management and search in repositories
- Evaluation of students' tasks
- Collaboration (to facilitate interaction and teamwork via different groupware tools)

Important characteristics of the MLS are using device-independent applications, small learning objects, and modular structure of courses, as well as ensuring extensibility and reusability. Some additional features could be added such as reminders, location services, campus navigation, or knowledge management.

5.3 M-Learning with Tablets

5.3.1 Application of Tablets in Bulgarian University

The overview of mobile devices suggested that they have a great potential for usage in education; however, the application should take into account their disadvantages and adapt the educational design. Among the devices offered on the market, tablets were considered the most appropriate as they possess hardware capabilities close to those of a laptop but have a smaller size, e.g., with 5–10 in. screen size. Tablets possess unique capabilities and functions (Dulev 2011):

- Own operating system (e.g., Windows 7, Android, or iOS)
- Improved Internet connectivity via different wireless technologies and by using various communication protocols
- Support text, video, and audio files with various extensions (e.g., for video files: avi, mp4, mkv, mov, flv and for audio files: mp3, wma, wav, ape, ogg, glac, aac)
- Availability of camera, internal flash storage, or micro SDHC (Secure Digital High Capacity) card slot
- Easy screen navigation—better accessible than laptops, especially in crowded places

Tablets give students the opportunity to work in larger groups. These mobile devices help maintaining an uninterrupted dialogue within the group, sharing and transferring resources. Every student is able to test his/her hypotheses and ideas and then share the results with the rest of the group. The advantage of this technology is the ability to constantly exchange information between students even while they are working on a specific task (Asenova 2011; Gourova et al. 2011).

During the last couple of years, tablets became very popular in Bulgaria. In addition to the device functionality, its usage by young people could be considered as one of the factors behind the trend of their application in the educational process (Asenova 2011). A small-size survey carried among students at Sofia University revealed that 40 % of all respondents possess a tablet, and most of the rest would like to buy one. The students use tablets mainly for entertainment, reading e-mails or e-Books, or searching the web. They consider that its introduction into the educational process might increase their motivation to learn and could support evaluation, self-training, teamwork, etc. The teachers, however, are more skeptical about tablet usage for educational purposes. They consider as a serious barrier for their usage the lack of technical expertise for dealing with this technology and the lack of training for teachers. The need for adapting educational methods, for redesign of course materials and activities so as to better suit the new technology, could also impose difficulties (Asenova 2011).

5.3.2 A Concept for M-Learning with Tablets

A huge number of papers exist in the area of learning design and learning styles. The authors, however, provide here their own practice-based approach. For example, the pedagogical design of a learning activity can be described by the following algorithm (Asenova 2011):

- Define the educational goals, and based on them, formulate the main types of activities.

- Adapt activities to a specific learning style.
- Break down these activities into separate actions and operations.
- Provide technological and functional support for the activities.

For the purpose of better organizing the m-learning in biology at SU, the authors considered the key characteristics of the main learning styles and on this basis created specific teaching strategies for each style (Table 5.3). Table 5.3 presents several options of the same learning activity and its educational goals, whereas each option is corresponding to a particular learning style. The characteristics of each style describe the way information is presented and processed by students, which defines the requirements for specific device functionalities in m-learning. According to the learning style chosen, the authors consider that the tablets should posses specific memory characteristics (e.g., for auditory/verbal style), ensure high transfer speeds (to support visual/verbal style and tactile/kinesthetic style), and support various audio and video presentation formats (Table 5.3). Students could find their preferred learning style before undertaking any learning activity. They undergo a test and, depending on its results, have the opportunity to choose the activity option and the corresponding tablet model. By using a tablet, students can choose how the course information is presented, how to receive instructions, and how to work on given tasks—in a group or individually. When working in a group environment, mobile technologies allow sharing of resources, opinions, and uninterrupted communication between group members in real time (Asenova 2011).

It is obvious that one of the big advantages of mobile technologies is the possibility of organizing different learning activities and at the same time creating versions of these activities based on particular teaching methods and strategies and learning styles. The application of mobile devices in education could be successfully used along with more traditional forms, thus providing students with equal access to information at any time and anywhere. In this context, the usage of mobile devices (including tablets) could make the learning and teaching processes more efficient and ensure more useful and better suited educational resources and activities (Asenova 2011).

5.3.3 Integrating Video Lectures in M-Learning

The authors considered that learning could be facilitated using various lecture formats: text, audio, or video. This provides students a flexibility to choose the most appropriate for them type of digital materials. It was taken also into account that video lectures could support the faster absorption of learning materials, the usage of interactive models, and the demonstration of complicated devices, details, and processes (Dulev et al. 2010). It was tested that tablets support also visualization of video lectures, which was considered as an essential opportunity to integrate in m-learning various content types.

Table 5.3 Correspondence of learning styles and teaching concepts, tools, and activities (Asenova 2011)

Teaching concepts	Requirements for tablets' functional capabilities	Example of educational activity in biology
1. Visual/verbal learning style		
• The student learns best when the information is presented in a visual and/or written format • The information is presented using contrasting colors indicating different topics and their priority, drawings, charts, diagrams, lists of key terms, etc.	• Support for a large number of audio and video codecs (avi, mp4, mkv, mov, flv, mp3, wma, wav, ape, ogg, glac, aac) • Communication protocols supporting transfer speeds of at least 2–4Mbps, i.e., 802.11b/g and 802.16 • Large screen: 8–10 in. • Suitable tablets: Archos 9PC tablet, Archos home tablet 7, Archos 5G	• Educational activity/task: –List and describe the main stages of creating a project-based education style in the field of biology –List the advantages and disadvantages of this style of education, and prove why it is better than the traditional way –Case 1: The general purpose of the activity is explained to the students, and they are provided with a written description of the algorithm of the educational activity. The students watch a video which shows an example of project-based education in biology. This is followed by a discussion of all aspects of this type of education

(continued)

Table 5.3 (continued)

Teaching concepts	Requirements for tablets' functional capabilities	Example of educational activity in biology
2. Visual/nonverbal learning style		
• The student learns best when the information is presented visually in the form of a chart or an image • The information is presented using videos, maps, and diagrams, symbols; the learning aids should be very well illustrated	• Support for a large number of audio and video codecs (avi, mp4, mkv, mov, flv, mp3, wma, wav, ape, ogg, glac, aac) • Communication protocols supporting transfer speeds of at least 1–2Mbps, i.e., 802.11b/g, 802.16 , and 3G • Screen size: 5–10 in. • Suitable tablet: Archos 9PC tablet	• Educational activity/task: –List and describe the main stages of creating a project-based education style in the field of biology –List the advantages and disadvantages of this style of education, and prove why it is better than the traditional way –Case 2: The general purpose of the activity is explained to the students, and they are provided with a written description of the algorithm of the educational activity. The students watch a video which shows an example of project-based education in biology
3. Auditory/verbal learning style		
• The student learns best when the information is presented in an audio format or oral form • The information is presented using recordings of lectures and any type of group work such as group discussions	• Large internal storage and an additional memory card slot • Any kind of communication protocol is an advantage • Screen size: 5–10 in. • Suitable tablets: Archos home tablet 7, Archos 5G	• Educational activity/task: –List and describe the main stages of creating a project-based education style in the field of biology

		–List the advantages and disadvantages of this style of education, and prove why it is better than the traditional way –Case 3: The general purpose of the activity is explained to the students, and they are provided with an audio description of the algorithm of the educational activity. They discuss the activity in a group setting. The students are given an audio recording of interviews with biology teachers who are sharing their experiences with project-based education
4. Tactile/kinesthetic learning style		
• The student learns best when can physically manipulate an object or carry out a physical activity • The information is presented by taking advantage of senses, experimentation. Standard lecture presentation should be avoided regardless of format	• Support for a large number of audio and video codecs (avi, mp4, mkv, mov, flv, mp3, wma, wav, ape, ogg, glac, aac) • Communication protocols supporting transfer speeds of at least 2–4Mbps, i.e., 802.11b/g and 802.16 • Suitable tablets: Any Windows-based tablet, e.g., Archos 9PC tablet	• Educational activity/task: –List and describe the main stages of creating a project-based education style in the field of biology

(continued)

Table 5.3 (continued)

Teaching concepts	Requirements for tablets' functional capabilities	Example of educational activity in biology
		–List the advantages and disadvantages of this style of education, and prove why it is better than the traditional way –Case 4: The student will then be required to create a model of overall project-based education process by arranging. The students are presented with parts of a movie dealing with the organization of project-based educational activities in biology

Video lectures could represent an essential element of the m-learning system. They could integrate presentations with dynamic images and animations, making sound track of the information, etc. The video lectures should be built on a modular principle and include screen, slide navigation, and presentation navigation. Most platforms supporting video lectures offer also text which is visualized in a separate window. Some of the main criteria put on video lectures modules and platforms include the following (Dulev et al. 2010):

- Clear pedagogical model for audiovisual presentation
- Easy access to platform services
- Easy navigation in the video lecture and the slide
- Short content of the module
- Storage of the video material with high quality
- Platform that generates different sizes and qualities for different environments, e.g., online, local, mobile

Video lectures could be designed by using specialized software, which could be part of an -learning platform or additionally integrated program. In most cases, video lectures are designed on bases of presentations prepared by using MS Office or OpenOffice, whereas the sound and picture could be added to each slide or recorded separately and after that assembled via video and audio processing application. It is advisable when storing the ready video lecture to use more than one format (e.g., mpeg2/mpeg4, flv). Using mpeg4 or mpeg2 format would allow the conversion of video lectures to different formats according to the environment and devices to be used. In addition, the sound of the lectures could be in the formats mp3, AC3, or AAC as they are widely used and could be converted easily. According to the environment (online, local, or mobile device) the screen size and the quality also vary. By smart phones or mobile devices, the video lectures should have different designs as on desktop computers due to the smaller screen size, colors supported, and resolution. On Fig. 5.4 is shown a visualization of the video lecture on a smart phone or another mobile device (Dulev et al. 2010).

Short surveys were carried out at SU for applying tablets in education and especially for access and usage of the content available on the widely used in Bulgarian universities e-learning systems based on a Moodle platform—open software designed for educational purposes. The performance of different devices was tested at SU browsing through the content available on the Moodle platform. The tests showed that the lectures could be clearly displayed and easily read using a tablet. Different file formats were also tested, whereas opening of text documents (e.g., doc or pdf) did not create any difficulties. However, the tablets with lower hardware capabilities exhibited a tendency for choppy picture and sound when viewing video lectures (e.g., in flv and mov formats). In order to overcome this choppiness, it could be suggested to students to download the lectures either on the tablet's internal storage or the MMC (Multimedia) card (Dulev 2011).

It is obvious that video lectures provide certain advantages in learning; however, it is difficult to ensure on all mobile devices the necessary presentation quality. As shown in Table 5.3, video lectures require higher communication speeds in order to overcome the visualization problems which might appear.

Fig. 5.4 Video lecture on a mobile device (Dulev et al. 2010)

5.4 Integration of M-Learning in Education

5.4.1 A Concept for M-Learning System

M-learning systems are not very popular in Bulgaria, although several pilot projects are already under way (Georgiev et al. 2004; Georgieva et al. 2011; Dulev et al. 2010). The widely adopted model in Bulgaria for e-learning is based on the Moodle platform, where teachers create courses and upload educational content for students, mainly lectures, study tasks, self-study materials.

The outline of the LMS is given on Fig. 5.5. It is a typical structure also for e-learning system. The differences come from the requirements for digital content presentation (to be used on mobile devices and desktop computers) and the opportunity for different types of content—text, audio, and video. The MLS functionality should support many students. Such systems are often built on blade servers. The main functional servers used in the system include the following (Dulev et al. 2010):

- Central web portal—which provides access from the web portal of the university to the MLS resources
- Students' management—server with students' profiles, courses selected, etc.
- Server for databases
- Data repository—server for all types of documents and files (mpeg, doc, pdf, etc.)
- Audio and video platform—the server allows integration with the system for remote access for students and lecturers. Similar platform is WebEx (http://www.cisco.com/en/US/products/ps10352/index.html)

The most essential for the system is to ensure device-independent applications, modular structure of courses, and extensibility and reusability of content. As most Bulgarian universities have developed different systems for students and teachers administration, digital learning content provision, and access to groupware tools and scientific databases, it is necessary to provide a single sign-in to all ICTs supporting learning and teaching in order to facilitate their usage. A knowledge management system supporting all processes in an educational institution could facilitate users and especially accessing various functionalities, navigating between applications, and finding the knowledge they need.

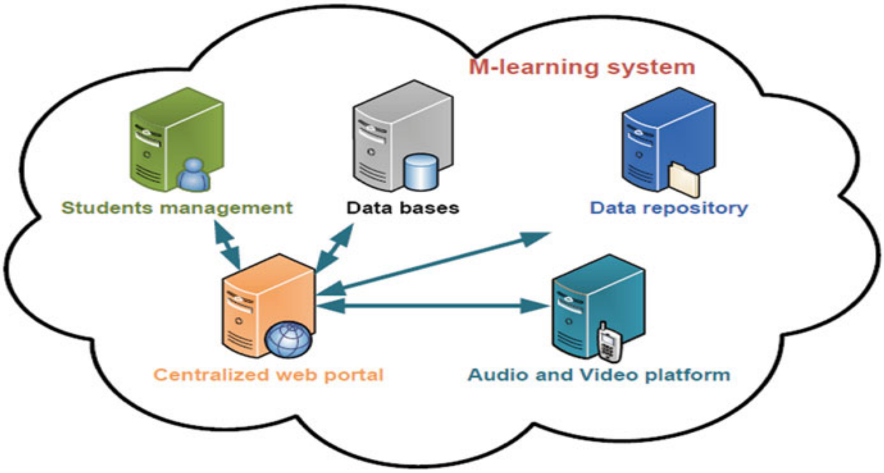

Fig. 5.5 M-learning system (Dulev et al. 2010)

5.4.2 *Course Design for Lifelong Learning*

Within the Leonardo Da Vinci—Multilateral Project "Professional learning for adults on the move" (MOVE-ON) was acknowledged that mobile device producers have recently offered on the market sophisticated mobile devices like iPhone, iPad, Blackberry, Google Nexus, and tablets, which have already demonstrated a good potential for mobile learning. At the same time, the knowledge-driven economy requires from employees to learn continuously and to adapt rapidly to the changes in their working environment, thus to renew, update, or certify knowledge and skills in order to remain competitive in their workplace. Therefore, the MOVE-ON project set as its goal to develop and demonstrate a new practice for adult lifelong learning and personal development based on widespread mobile devices. It focused in particular on the design of a novel m-learning pedagogical approach, of an innovative and attractive all-inclusive m-learning system, and learning material (courses) that cover a selection of subjects, e.g., project management, logistics, and sales management skills. The MOVE-ON model focuses, in particular, on the following dimensions:

- Technology: devices, hardware, networks
- Individuals: learners and teachers (profiles, learning habits, needs)
- Societal: team, departmental, organizational, interorganizational levels (social interactions, dynamics influencing learning)
- Content: messages, SMS campaigns, voice, reference, courseware, rich media
- Delivery mode: lectures, readings, exams, assignments (synchronous–asynchronous)

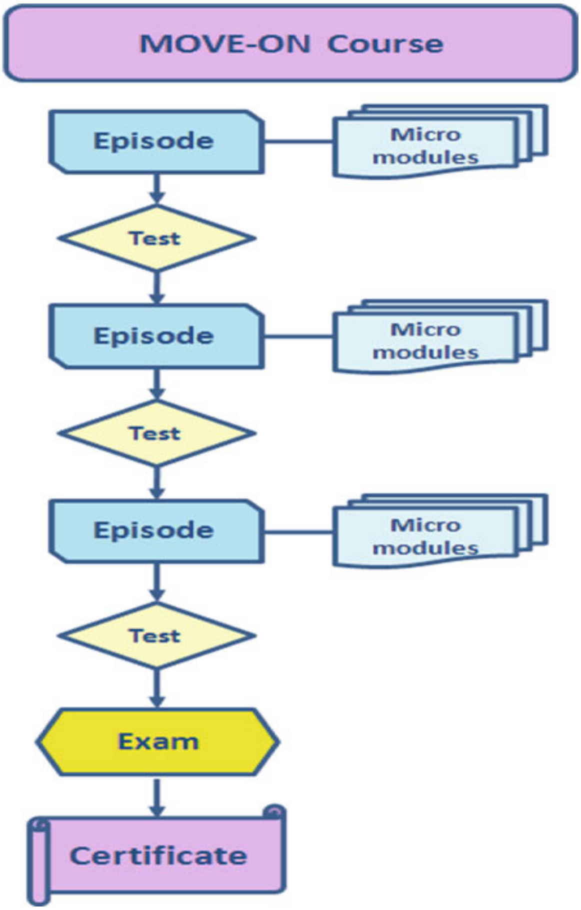

Fig. 5.6 The MOVE-ON course structure (MOVE-ON 2011)

The structure of the MOVE-ON courses is given on Fig. 5.6.

Each course is characterized by the following information: title, educational institution providing the course, author(s), version (a course may be updated at a certain point), date published (the date the course became available for downloading), educational objectives, target audience, prerequisite courses, duration, list of episodes (titles), course file size (to estimate if the phone has enough available memory), course evaluation (measured as the average of learner evaluation, min 0, max 5, presented by stars), and course comments (a combination of free text comments entered by previous course learners). In order the courses to be accesses on smart phones, the micromodules are of the following types (MOVE-ON 2011):

- Text. Short paragraphs, bullet/numbered lists, long enough to fit on a mobile smart phone screen and be easily read. Text may resemble the format of a presentation slide.
- Pictures/photos.

- Animations. Animations present information in a lively way. They may include audio material.
- Games. Similar to animations but with user interaction.
- Videos. Prerecorded material.
- Questions. Several closed-type questions (see below).

The most common interactive learning elements, such as question types, exercises, and quizzes suitable for the MOVE-ON learning objectives include the following (MOVE-ON 2011):

- Multiple choice questionnaires: The learner chooses from multiple answers in response to a question. Possible answers may be single or multiple (e.g., more than one answer is correct).
- Crosswords: The learner must write the correct answer to specific numbered questions in a grid of white and shaded squares. The aim is to fill the white squares with letters, forming words or phrases, by solving clues which lead to the answers (from left to right and from top to bottom). The shaded squares are used to separate the words or phrases.
- Drag and drop: The learner selects a virtual object by dragging it to a different location or onto another virtual object.
- Find the pair (matching): Among a list of words, sentences, or objects, the learner must select items that match according to the question objectives (e.g., match the capital with the country with the two lists "Germany, Italy, Japan" and "Berlin, Rome, Tokyo").
- True/false: The learner selects from two options (True or False) in response to a question.
- Connect items (finger draw path): The learner must connect with a finger drawing path a few words (or objects) positioned in random order, in order to compose the correct sequence.
- Find the right order: Similarly to the finger draw path, the learner must select each item (word or image) in the right sequence/order.
- Find odd: Among a list of words, sentences, or objects, the learners must select the odd or the incorrect one.
- Speed answer: The learner answers a series of questions: an initial amount of time is given; the right answer increases time available, and wrong answer decreases it.
- Simulations: The learner can experiment the eventual real effects of alternative conditions and courses of action.
- Concept map: The learner must fill in blank spaces in a concept map with the correct word or object in order to create the correct relationships among concepts.
- Animation games: Stories presented in an animated way that pose decision dilemmas to participants.
- Decision tree exercises: Participants are called to make a choice—story unfolds according to users' decisions.

Fig. 5.7 Block diagram for Iphone and Ipad m-learning platform

Fig. 5.8 Visualization of the courses

A block diagram for Iphone and Ipad m-learning platform designed for the project is given on Fig. 5.7, and the visualization of the courses on mobile devices on Fig. 5.8.

5.5 Conclusion

This chapter showed that m-learning provides great opportunities for learners at any age, at any time and everywhere. The user-friendly interface, the technical features of mobile devices, and the communication opportunities are well appreciated by users. At the same time, there are still more demands for motivating teachers to overcome the need for a change in providing mobile content or using it for learning, as well as for developers of mobile devices and applications to ensure their interoperability and security. M-learning is not going to fully replace traditional learning approaches; however, it provides an excellent option for teamwork, interactivity, and seamless collaboration of students in a group or with their teachers. It is a new trend in education reflecting the changes in technologies but also the habits of the new generation of computer-savvy students. The functional abilities of mobile devices for text, audio, and video lectures pointed out in the paper are a motivation factor for widely using these opportunities in future m-learning systems. Several challenges for m-learning still remain—to develop m-learning standards for learning objects, to ensure device-independent and interoperable applications, etc. The development of knowledge management systems at Bulgarian universities with single entry to all university resources could further facilitate users. The most essential is, however, to train teachers and motivate them to use the new educational opportunities available with the development of ICTs in order to better meet students' demands and ensure higher quality of teaching and better prepare future employees to the labor market.

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Chapter 6
Activity Theory and M-Learning in the Teaching of Calculus

Silvia Cristina Freitas Batista, Patricia Alejandra Behar, and Liliana Maria Passerino

6.1 Introduction

As access to information increases regardless of time and distance, the role of education, especially that of formal education, has been questioned and challenged. Relations among education, society, and technology are progressively more dynamic—a context in which mobile learning (m-learning) may contribute as research advances in the area (Traxler 2009).

M-learning is a research field which aims at analyzing how devices can contribute to learning and presents features such as interactivity, mobility, group work, learning in authentic situations, among others. It is, therefore, an area that demands further studying, both in its technological and pedagogical aspects (Traxler 2009). Considering the special features of m-learning, it is important to analyze theories that can support it. Thus, this study discusses activity theory (AT) as a theoretical framework for m-learning.

According to AT, which was developed primarily by Russian psychologist Alexei N. Leont'ev, activity is the process that promotes mediation between the human being and the reality to be changed. This is a dialectic relation, as not only the object is changed, but the individual is also psychologically modified (Núñez 2009). Studies in literature have indicated factors that justify adoption of AT as a theoretical framework in m-learning projects (Sharples et al. 2005; Waycott et al. 2005; Uden 2007; Liaw et al. 2010).

S.C.F. Batista (✉)
Instituto Federal Fluminense,
Campos dos Goytacazes, RJ, Brazil
e-mail: silviac@iff.edu.br

P.A. Behar • L.M. Passerino
Universidade Federal do Rio Grande do Sul,
Porto Alegre, RS, Brazil
e-mail: patricia.behar@ufrgs.br; liliana@cinted.ufrgs.br

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This chapter describes and presents considerations about two case studies involving cell phones in Calculus I classes. The methodology was based on AT and took into consideration technological resources in addition to cell phones. The case studies took place in the first semester of 2011, with two college-level groups of students at a federal institution (traditional classroom). Section 6.2 presents the basic concepts of AT and discusses how it has been adopted, in literature, as a framework for m-learning projects. An overview of Calculus I and the methodology used in its teaching are presented in Sect. 6.3. In Sect. 6.4, data collected are considered from an activity theory perspective. Section 6.5 closes by presenting final remarks about this study.

6.2 Activity Theory

Activity theory focuses on activities developed by individuals and on the diverse relations resulting from these activities. Activity is considered responsible for the mediation between humans and the reality to be transformed. According to this theory, the activity is responsible for the mediation between humans and the reality to be transformed.

AT is based on Vygotsky's key concepts, such as mediation, internalization, and development of higher mental functions (Núñez 2009). Activities may vary according to form, method, emotional intensity, and time and space requirements. However, the main distinguishing feature of activities is the difference among their motives (Leont'ev 1978). Motives may be material or mental; they may be present in perception or, exclusively, in the imagination or thought (Leont'ev 1978). It is important to consider that certain activities are more relevant for the subsequent development of the individual than others and, therefore, are considered as the main ones (Leont'ev 2001).

It is also essential to show the difference between two concepts: activity and action. Activities are processes psychologically characterized by their purpose as a whole. This final objective of the activity must always coincide with the reason that triggered the individual to act (Leont'ev 2001). An action is a process that aims at collaborating to reach the motive of the activity. Thus, for an action to be executed, its objective must be understood in association with the motive of the activity it belongs to (Leont'ev 2001).

However, an action can be transformed into an activity. The motive can become the object of an action and, thus, the action becomes an activity. The transformation of motives comes from the fact that results of an action are more meaningful, in certain situations, than the motive that actually elicited it (Leont'ev 2001).

Furthermore, operations must be defined. These represent how actions are performed. Actions are related to objectives, and operations are associated to conditions (Leont'ev 1978). In short, an activity is regulated by motivation and comprises actions guided by distinct objectives. Each action, in turn, requires several operations which adapt to specific conditions. An activity reveals its motivation, an action reveals its goal, and an operation reveals the conditions of the actions (Leont'ev 1978).

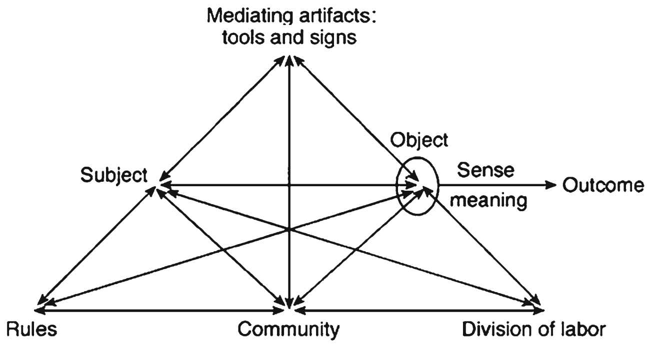

Fig. 6.1 The structure of a human activity system—second-generation activity theory model. *Source*: Engeström (1987, p. 78; 2001, p. 135)

Nevertheless, Engeström (1987) says that some studies based on AT emphasized the role of mediation in the subject–object relation, but did not focus, in a meaningful way, on the social and communicative factors. The author then proposed an expansion of the theory, aiming at representing the social-collective context within an activity system by adding elements related to the community, rules, and division of labor. However, for a more comprehensive view, one should look up a prior study (Engeström 2001), in which the author emphasizes the existence of three generations of AT.

The first generation is centered on Vygotsky, who introduced the concept of mediation. The basic Vygotskyan triangular model presents the stimulus-response connection, mediated by tools and signs. The second generation has Leont'ev as the main representative (Engeström 2001) and Engeström himself as a collaborator. Emphasizing collective activity, Engeström (1987) proposed the diagram representing the second generation of AT (Fig. 6.1), which shows the various elements of the activity system and its interrelations. Engeström (1987) added social aspects related to activity to the original Vygotskian model.

Figure 6.1 shows that the relationship between subject and object is mediated by artifacts (tools and signs), which is represented by the basic Vygotskyan triangular model. However, in addition to artifacts, there are also social mediators of activity—the rules, community, and division of labor—all indicated at the bottom of the diagram (Engeström 2001). This means that the relationship between subject and object is also mediated by these components. In the diagram:

- Subject can be an individual or a subgroup of the community.
- Object refers to the "raw material" or problem at which the activity is directed.
- Mediating artifacts (tools and signs) help turn the object in the result of the activity.
- Community is composed of various individuals and/or subgroups who share the same general object, and its features distinguish it from other communities.
- Rules refer to the explicit and implicit regulations, norms, and conventions that guide actions and interactions within the activity system.

- Division of labor refers to both the horizontal division of tasks between the members of the community and to the vertical division of power and status.

In the diagram, the oval figure indicates that object-oriented actions are always, implicitly or explicitly, characterized by ambiguity, surprise, interpretation, sense making, and potential for change (Engeström 2001).

According to Engeström (2001), AT's third generation must develop conceptual tools in order to understand dialogue, multiple perspectives, and networks of interactive activities. The author also proposed a model for the third generation of AT. Nevertheless, this model is not presented here as both the studies discussed in Sect. 6.2.1 and the case studies described in this chapter follow Engeström's model for AT's second generation (Fig. 6.1).

For Engeström (1987, 2001), the focus is always on the collective activity. In his works, he emphasizes the conflicting nature of social practices, which regards instability (internal tensions) and contradiction as forces of change and development.

As to learning, AT considers it as an activity since it aims at satisfying cognitive needs (Núñez 2009). In this approach, formal learning has a social character which goes beyond the individual, as it takes place in active interaction with other people, through collaboration and communication, and mediated by tools and signs (Núñez 2009). Davýdov (1982), based on contributions by Vygotsky, Leont'ev, and Elkonin, expanded the characterization and understanding of the learning activity. The objective of the learning activity, in Davýdov's view (1982), is the domain of the theoretical knowledge, that is, the domain of cultural symbols and instruments available in society and obtained by learning in the various fields. Davýdov (1982) distinguishes two types of thought: empirical and theoretical. Empirical thought has an external and immediate nature; it is related to practice. Theoretical thought, on the other hand, is related to the essence and to the internal relations among objects and phenomena. For Davýdov, teaching strictly based on empirical thought does not result in the mental development of the learner.

Regarding development of the theoretical mathematical thought, Davýdov (1982) says that each topic in the curriculum should start by a detailed introduction, presenting situations which originated the need of the respective theoretical concepts. Following, concepts should be built from these steps: (1) student guiding in a problem situation, in which the solution requires a new concept; (2) identification of the relation that grounds problem solving; (3) establishment of a symbolic model that allows for the study of properties in "pure form"; and (4) identification of the properties of the observed relation, through which it is possible to infer the conditions and resolution methods of the original problem (Davýdov 1982).

In this study, AT is used according to the principles proposed by Leont'ev and contributions by Engeström, particularly those regarding collective activities. Furthermore, Davýdov's contributions are used due to their relation to the teaching of mathematics.

6.2.1 Activity Theory as Theoretical Framework for M-Learning

The ability of young people to deal with mobile technologies, the popularity of these technologies, and the development of specific applications are factors that may contribute to the introduction of these resources in pedagogical practices. Furthermore, the practicality of using these tools is a factor that is noteworthy.

However, we must critically analyze the motivational and educational potential of these devices in education because there are limitations, for example, screen size, keyboard, and storage capacity, and also issues such as distractions and increasing indiscipline.

The use of mobile devices in education requires analysis of pros and cons and development of appropriate pedagogical practices. To this end, research becomes necessary in various educational levels. It is agreed that m-learning involves much more than issues relating to mobile technologies. Thus, studies that examine theoretical framework that can support activities in the area are essential.

This subsection presents an analysis of studies that show the potential of AT to serve the specific features of m-learning. This does not mean that other theories cannot be used. Patten et al. (2006), for example, think that constructive/constructionist, contextual, and collaborative principles are, in general, adequate to m-learning. Therefore, this section focuses on AT but keeping in mind that other frameworks could also be used.

Sharples et al. (2005) propose five questions to be tested in the identification of a theory for m-learning: (1) Is the theory significantly different from traditional approaches? (2) Does it allow checking mobility of learners? (3) Can it be used both in formal and informal learning? (4) Does it theorize learning as a social and constructive process? (5) Does it allow understanding learning as a personal and situated activity mediated by technologies?

According to the authors, AT provides adequate answers to those questions because it considers learning as an active process in building knowledge and skills by means of activities within the context of a community. In addition, it supports not only the continuous process of personal development but also the fast conceptual changes of contemporary society. Thus, Sharples et al. (2005) endorse AT to support m-learning activities.

Waycott et al. (2005) also analyze AT contributions to m-learning, among which are the following: (1) possibility of analyzing how the user adapts to the tools, according to his/her practice and preferences, and how they transform the object of the activity and (2) considerations on contradictions (Engeström 1987), which contributes to the understanding of the impact of new technologies in learning—contradictions to the new tools help to solve as well as those created by their use.

Confirming these ideas, Uden (2007) defends that AT can support m-learning projects. According to the author, AT allows for the analysis of the main elements of the context in which the activity takes place and how they may influence learning. The context comprises internal aspects (motivations, objectives, among others) and external ones (artifacts, other people, environmental aspects, etc.). There are also specific aspects related to mobile technologies (including technical features, usability, and mobility). Furthermore, AT incorporates a strong notion of mediation (activities are mediated by artifacts, both internally and externally), of history (activities develop and change), and of collaboration (an activity is carried by one or more individuals, aiming at obtaining desired results, within a community, and according to a set of rules).

Complementing the discussion, Liaw et al. (2010) see the AT as a lens that contributes to the understanding of the learning process, allowing the analysis of its complexity. The authors present indicative of the influence of four factors (students' autonomy, system functions, satisfaction with these functions, and system activities) acceptance of an information management system for m-learning. These indicators were collected via a survey supported by AT.

Therefore, AT, as seen by the aforementioned authors, has the potential to support m-learning—an area characterized by interactivity, mobility, group work, and real-life learning environments.

6.3 Case Studies: Methodological Procedures

In teaching Calculus I (first semester of 2011) to two college-level classes at a federal institution, we conducted case studies applying a methodology using cell phones. These classes were first period of information systems, bachelor's degree (daytime classes), and first period of systems analysis and development, technologists (evening classes). Both were conventional classroom courses with the same amount of class time (80 contact hours[1] per semester) and content (limits and continuity, derivatives, integrals).

The course management system used was Moodle, with MLE-Moodle[2] (a plugin that enables extending Moodle functions to cell phones). In addition to these, several other aspects were common to both classes (content, materials, group activities, integration of different technological resources, among others). Therefore, it was possible to organize a series of common strategies for both courses, such as:

- Use of technological resources, especially mobiles, as mediating arwtifacts.
- Group activities based in problem solving.
- Discussion of the historical origin of each topic (limits, derivatives, and integrals).

[1] Each contact hour equals 50 min of class time.

[2] Available at http://mle.sourceforge.net/mlemoodle/index.php?lang=en.

- Incentive to generalizations, thus contributing to the development of mathematical thinking (the objective is not the solution of specific questions, but the acquisition of tools to solving various questions).
- An understanding that the student is the agent of his learning process, that the teacher acts as mediator, and that the exchange of knowledge among peers is an essential factor.

According to AT, activities are a collective system with tools, rules, and division of labor. People interact to transform the object aimed at a common motive. The subject Calculus I, in each of the observed classes, was considered as activity system. In such systems, several actions were carried out, aiming at a greater motive—acquisition of knowledge related to the program content. According to Núñez (2009), the result of a learning activity is represented by the content assimilated, the new ways of acting, and the attitudes and values formed in conformity with educational goals. Thus, considering the activity structure proposed by Engeström (1987), Fig. 6.1, the following elements of the activity system were identified:

- Subject: each Calculus I student in two courses—information systems (bachelors) and systems analysis and development (technologists).
- Knowledge object: topics in Calculus I (limits and continuity, derivatives, and integrals).
- Expected results: (1) development of mathematical thinking, (2) mathematical foundations related to Calculus I contents, (3) ability to apply Calculus I knowledge and methods in problem solving by stimulating hypothesis formulation and selection of strategies of action, (4) interpretation and critical analysis of the results, and (5) ability to use, in a conscious way, resources found in calculators, computers, and mobile phones in solving math problems.
- Tools and signs: (1) tools—cell phones, teacher's notebook, LCD 42″ TV sets available in the classrooms, wireless Internet connection available in the institution (including access for students' mobile devices), applications and quizzes for cell phones, computer software, calculators, Moodle learning platform (with MLE plugin), books, and exercise sheets and (2) signs—language, algebraic symbolic systems, mathematical models, and other conceptual tools related to the topics of Calculus I.
- Community: two communities, both composed by students from each class; teacher; course coordinators; monitor; and department directors of the aforementioned institution. It is important to emphasize that the school offers computer labs for academic activities.
- Rules: main guiding rules in the first semester of 2011 were (1) two grades each consisting of student participation in the activities (10%), extra class work (20%), and individual tests (70%); (2) group activities based on problem solving and supported by learning resources for cell phones; and (3) participation in discussion forums available in the virtual environment.
- Division of labor: (1) students—agents of their learning, their role was to act actively in the activities developed, individually or in groups, aiming at learning the content; (2) teacher—responsible for organizing and guiding activities intentionally directed to the development of mathematical thinking, with well-defined objectives (the student should be fully aware of what he was searching for); (3)

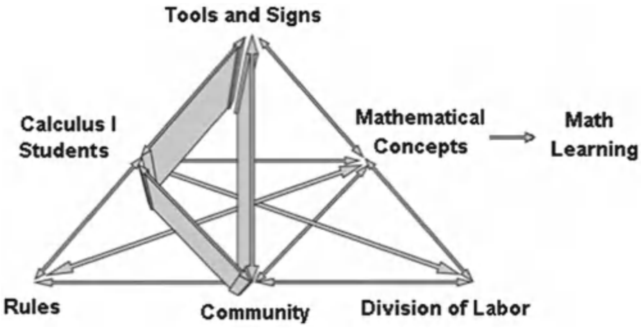

Fig. 6.2 Relationship between subject-community-tools/signs

monitor—support for the actions of the discipline, contributing to the reduction of difficulties; and (4) people related to coordination—issues management courses.

The various mediating relations which take place among these elements, indicated in Fig. 6.1, are an evidence that learning results from a collective activity, in which each component influences the whole. Thus, these elements and the relationship among them were always taken into consideration throughout the case studies.

6.4 Results: Considerations in View of Activity Theory

6.4.1 Preliminary Data

In the beginning of the school semester, with the objective to guide the actions being developed in the case studies, data was collected through a questionnaire. This questionnaire had questions related to cell phones, to the use of resources, to their ability of using the keyboard, and to the use of mobile devices in education, among other topics.

The purpose of this initial data collection was to seek information about the subject-community-tools/signs triangle, shown in Fig. 6.2,[3] which describes the context of case studies.

The questionnaire was answered by 27 bachelor students and 41 technologists. Data was analyzed and showed that:

- The mean age in the two groups was, respectively, 20 (standard deviation—3.2) and 23 (standard deviation—5.0) years of age.

[3] An adaptation Engeström's diagram (1987), shown in Fig. 6.1.

- All students had cell phones, regular or smartphones, but with high predominance of regular devices (nearly 26% of the bachelor students had smartphones and approximately 17% of the technologists).
- Among the bachelor students, about 70% of the cell phones had Java ME platform, and among technologists, this percentage was approximately 61%.
- Regarding Bluetooth, about 59% of bachelor students' devices and approximately 76% of technologists' cell phones had this technology.
- As to the ability of using the phone keys, no student rated it as "very bad," and only one rated it as "bad."
- All students were in favor of using mobile devices in education, but 54 of the 68 students (around 79%) said they had never used any software for studying math.

Due to the fact that not all students could use the Internet on their phones, a strategy was devised in which quizzes on the subject were presented in two different ways: via MLE-Moodle (for those with Internet connection) and via MyMLE,[4] an open source computer program that allows the creation of quizzes for mobile phones on Java ME platform, with no need of Internet connection.

After analyzing data about cell phones, applications that run on Java ME were sought to achieve the greatest number of students. Graphing calculator[5] and Graph2Go[6] were chosen. Both apps are free and require Java ME platform. They enable graphic analysis of functions and were used to support problem-solving activities.

Guidelines to using the apps were available in the Moodle environment, as well as mobile tags (2D codes, similar to bar codes but with two dimensions) referring to the URLs, in order to facilitate access for those with Internet connection. Students without such connection transferred the apps to the computer and, then, sent them to their phones via Bluetooth or USB cable, for instance.

Therefore, mobility, in the discipline described here, was considered in the use of (1) MLE-Moodle resources, which allow access to the course at any time and location; (2) apps for cell phones, which took place in the classroom or not; and (3) quizzes which, like the apps, could be accessed from anywhere and with no need of an Internet connection.

6.4.2 Overall Results

The analysis of an activity, understood as a collective system, requires the understanding of the individual, the different elements, and the interaction among them.

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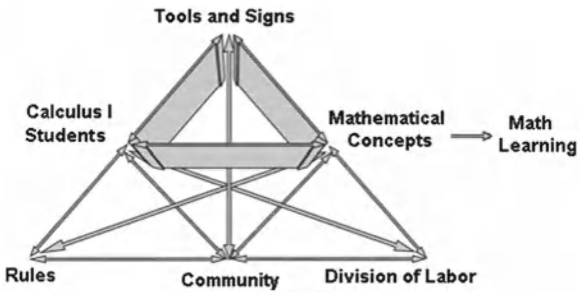
[4] http://mle.sourceforge.net/mymle/index.php?lang=en&page=download.php.

[5] http://www.getjar.com/mobile/36442/graphing-Calculator/.

[6] http://www.math4mobile.com/download.

Fig. 6.3 Relationship between subject-tools/signs-object of knowledge



As such, there are several multiple factors acting in a collective construction. As mentioned in Sect. 6.3, Calculus I, in each of the observed classes, was considered an activity system.

In the beginning of the semester, most students were entering their college program. Contents in calculus were quite different for them, as they demand a number of prerequirements and abstractions. Therefore, students had to become familiar with the pedagogical proposal for the subject calculus, as well as the methodology, strongly supported on technological resources.

As most of them didn't have experience using educational software, even typing functions in the graphing calculator was a novelty for most learners (even though this kind of typing is similar to most math computer programs).

It is important to take into account that knowledge, according to AT, is internalized in a particular way, being processed and transformed according to the individual's reality and to his historical experience. Thus, students' initial difficulties can be associated to their entering a college program, to their prior educational experience (which, in general, does not make use of digital technologies as pedagogical resources), and, also, to the specific characteristics of calculus. At the start of the school semester, students did not feel they were members of a group, as they were still getting to know one another so that the notion of collectiveness was still being built. In other words, understanding initial difficulties demands understanding, even if somewhat superficially, the particular context of those students in their process of joining the institution.

In this section, data of the subject-tools/signs-object of knowledge triangle shown in Fig. 6.3[7] are analyzed.

After the monthlong stage of adaptation, it was possible to observe that the adopted strategies were being developed in a more natural way. Students became more familiar with the various technologies. According to Wells (1998), when the individual uses tools to reach the objective of an action, this can be understood as an operation, the means through which the action is performed. However, when students are still learning how to use the tools, the use itself is still an action since it is a conscious process. Thus, one can say that learners, at the beginning of the semester, dealt with technologies in the level of actions. As such actions reached a certain

[7] An adaptation Engeström's diagram (1987), shown in Fig. 6.1.

degree of maturity and started to be performed without demanding so much attention, technology use became an operation.

Problem situations were also gradually understood more easily. Their purpose was to change concepts into cognitive needs and lead the student to act consciously in search of solutions. It is not enough to know the definition of a concept; this must be used to solve different practical and theoretical situations (Núñez 2009). Developing problems proposed in the program was a group activity, by promoting interaction among participants and collective search for solutions. Apps for cell phones were tools that functioned as mediator between students and the object of knowledge. It must be stressed that of all cell phone resources, apps drew the most attention of students due to their convenience. Many learners used them with ease, at the level of operations.

It is also worthy reminding that not all students had cell phones with Java ME, a necessity for the pedagogical resources. Those who had no Java ME in their phones worked in groups with others who did so that they too could participate in discussions about the apps. As for the quizzes, it was possible to answer them in the Moodle environment. This alternative was open to all learners, but those who could do them via cell phone were stimulated to do so and, thus, optimize their timing.

Nevertheless, solving quizzes on cell phones, considered as important by students, was not a practical process for those who had no easy access to the Internet. They had to transfer and install each series of the quiz in the device. So, in general, students transferred only part of the series. For those who had connection to the Internet via cell phones, the process was simpler, as they could use the MLE-Moodle.

The analysis of the evolution of the activities in both groups shows good acceptance of the proposal for using technological resources in the educational context. In general, students had a responsible and cooperative attitude, making use of resources as mediating instruments in learning.

During the semester, we observe the development of the adopted strategies. In order to obtain other data related to them, a final questionnaire was used. Only those who concluded the school semester (13 bachelors and 26 technologists) answered the final questionnaire. It is crucial to mention that the college-level courses of the institution mentioned, regardless of the subject being taught, suffer from the problem of evasion, especially on the course day.

The final questionnaire consisted of statements, on which each student should be positioned in one of the options given: "Strongly agree," "Agree," "Neither agree nor disagree," "Disagree," "Strongly disagree," and "Not Applicable." The option "Not Applicable" (NA) is justified by the fact that not all students have adequate resources on their cell phones and, therefore, might not be able to evaluate all statements of the questionnaire.

One of the affirmative was "Apps were relevant resources for the resolution of problem situations." Table 6.1 presents the results. In the tables related to final questionnaire, 100% of the participants account for 13 bachelor students and 26 technologists.

The percentage of agreement in Table 6.1 was probably influenced by the fact that not all students were able to use apps on their cell phones. There are 69.23% of

Table 6.1 Apps: relevance

	Bachelor students (%)	Technologists (%)
Strongly agree	30.77	30.77
Agree	38.46	19.23
Neither agree nor disagree	7.69	15.38
Disagree	23.08	3.85
Strongly disagree	0	0
NA	0	30.77

Table 6.2 Apps: ease of use

	Bachelor students (%)	Technologists (%)
Strongly agree	7.69	19.23
Agree	30.77	26.92
Neither agree nor disagree	30.77	19.23
Disagree	7.69	0
Strongly disagree	23.08	0
NA	0	34.62

bachelor students and 50% of technologists in the options "Strongly agree" and "Agree," taken together. The best assessment by bachelor students is probably related to the fact that they were more active in the resolution of problem situations, which were supported by apps.

However, if the analysis is done by the percentage of disagreement, it is observed that only 3.85% of technologists and 23.08% of bachelor students disagreed. Therefore, in general, percentages in Table 6.1 were positive. They are consistent with the observed reality in the classroom.

Related to ease of use of the apps, the final questionnaire had the following statement: "Apps used in the course were easy to use." Table 6.2 shows the results obtained.

Data in Table 6.2 shows that the percentage of agreement, considering together the options "Strongly agree" and "Agree," did not reach 50% in any of the classes. A significant percentage opted for the alternative "Neither agree nor disagree." Thus, in the view of students, the ease of use of the apps can still improve. However, as already mentioned, this aspect is very much influenced by the equipment used; therefore, it is impossible to analyze clearly the same. A more rigorous analysis would require testing with similar phone models.

Related to the quizzes, the following statement was proposed: "Quizzes were relevant resources for learning content." Table 6.3 presents the results.

Quizzes also required Java ME platform, which not all had. Moreover, while these resources could be accessed at any time and place, they demanded, for many students, a transfer process to the cell phone. Technological evolution tends to minimize technical problems, but the relevance of quizzes for learning should always be reflected since they have low interactivity and slightly reflect the potential of mobile technologies.

Table 6.3 Quizzes: relevance

	Bachelor students (%)	Technologists (%)
Strongly agree	0	15.38
Agree	30.77	34.62
Neither agree nor disagree	61.54	15.38
Disagree	7.69	3.85
Strongly disagree	0	3.85
NA	0	26.92

Table 6.4 Quizzes: practicality

	Bachelor students (%)	Technologists (%)
Strongly agree	7.70	11.54
Agree	46.15	34.61
Neither agree nor disagree	46.15	15.38
Disagree	0	3.85
Strongly disagree	0	3.85
NA	0	30.77

In Table 6.3, the percentages show that, for technologists, these resources were more relevant than for the bachelor students. This fact is attributed to the context of the class of technologists, which had a greater number of students who felt more comfortable in front of a more conventional proposal, like the quizzes (direct application of the contents studied).

With regard to the practicality of quizzes, the following statement was proposed: "Quizzes were practical resources." Results are shown in Table 6.4.

Percentages indicate a better agreement rate than the observation, during the semester, it would take to consider, judging by the process of transfer of each block of quizzes (necessary for those who could not use the Internet). But once installed, the quizzes are simple to use. Again, percentages in Tables 6.3 and 6.4 on the option "Not Applicable" may be justified by the lack of Java ME on the cell phone.

A joint analysis of the options "Strongly agree" and "Agree" in Tables 6.3 and 6.4 allows us to observe that the percentage of technologists was slightly larger in the statement about the relevance (50%) than in the aspect practicality (46.15%). Among bachelor students, the evaluation of the practicality aspect (53.85%) was better than the aspect relevance (30.77%). These percentages are consistent with the characteristics of the classes observed. Some bachelor students had ease with content, as well as skill with technology, which allows us to understand the positions taken. The technologists generally had less time available for study. In this sense, an educational proposal more objective, like the quizzes, assumed a greater importance to them. But at the same time, the transfer of quizzes for those who have not had much time was an additional task.

With regard to access to the MLE-Moodle, the following statement was proposed in the final questionnaire: "Access to the MLE-Moodle on the cell phone, in general, was simple." Table 6.5 presents the results.

Table 6.5 MLE-Moodle: ease of access

	Bachelor students (%)	Technologists (%)
Strongly agree	7.69	7.69
Agree	23.08	7.69
Neither agree nor disagree	38.46	19.23
Disagree	15.39	3.85
Strongly disagree	7.69	3.85
NA	7.69	57.69

Access to the MLE-Moodle demands Internet, which requires devices with resources for that purpose and often involves cost. As mentioned, few students were able to use Wi-Fi provided by the educational institution due to technological limitations of their devices. The percentage of technologists in option “Not Applicable” is indicative of this situation. The evaluation of this statement may have been too influenced by the cost factor.

Therefore, it was not possible to analyze the usability of the MLE-Moodle, since the evaluation may have involved other factors. Furthermore, analysis of these factors also allows understanding that the data in Table 6.5, when presenting a low percentage of agreement, reflect the reality of the community considered.

For an overview of the pedagogical use of cell phones, the following statement was proposed in the final questionnaire: “Cell phones were relevant for the study of Calculus I.” Table 6.6 shows the percentages.

Given the context of two classes, the percentage of Table 6.6, considering jointly the options “Strongly agree” and “Agree” (61.54% among bachelor students and 65.38% among technologists.), was a good acceptance rate. In general, the technology many cell phones did not contribute to the pedagogical use of the same and thus also the percentage of disagreement is understandable.

6.5 Conclusion

In Calculus I, the use of cell phones was a strategy to expand the possibilities of accessing course materials, as well as to provide a more convenient technological support that would aid in analysis and discussions. The use of such devices, however, was a strategy associated to several others, making up a methodology fully grounded on AT.

In the case studies described, it was observed that the pedagogical use of students’ cell phones for educational purposes, under the conditions of the classes considered, still involves several complicating factors. These difficulties tend to decrease with technological advances and popularization of resources. However, a better understanding of these problems highlights the relevance of the study promoted.

Pedagogical use of cell phones will become more practical with the popularization of smartphones. Devices with many technological limitations constrain or prevent such use. However, the choice of apps yet will require care, because some are

Table 6.6 Cell phones: relevance

	Bachelor students (%)	Technologists (%)
Strongly agree	30.77	34.61
Agree	30.77	30.77
Neither agree nor disagree	7.70	19.23
Disagree	15.38	0
Strongly disagree	15.38	3.85
NA	0	11.54

specific to certain operating systems and some do not work in others. Resources that work in various models, such as those that require only the Java ME platform, can contribute to this. The analysis of minimum requirements is, therefore, a key issue for pedagogical use of apps in cell phones, unless a standard device is adopted.

As to AT/m-learning, the theory provides an adequate theoretical framework for actions in the area. According to AT, learning has a social character, going beyond the individual, as it takes place in the active interaction with others and mediated by tools and signs. Students are active agents of their learning process. So, the concept of learning, according to AT, embraces several aspects applicable to m-learning: social contexts, mediation with tools, collaborations, interactions, etc.

In the experiment, this notion proved to be entirely coherent, as AT contributed to (1) the organization of activities, allowing the understanding that several aspects should be taken into consideration since the system of activity has many dynamic and interdependent elements; (2) the development of actions, providing guidance, and keeping the specific mediating role of technological instruments, as well as the roles of students, teacher, and peers in the learning process; and (3) the analysis of the activity, contributing to the understanding of the nature of change that took place in the different stages and the internal contradictions that always come up in a system of activity. We should emphasize, however, that the option for AT does not reduce the relevance of analyzing and considering other theories to guide m-learning activities.

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Chapter 7
Medical Students Experience the Mobile Augmented Reality Blended Learning Environment (Marble®): An Attractive Concept for the Net Generation?

Urs-Vito Albrecht, Marianne Behrends, Herbert K. Matthies, and Ute von Jan

7.1 Introduction

Knowledge in forensic medicine is a valuable asset for doctors, enabling them to differentiate between everyday injuries and wound patterns of trauma due to assault, for example. By applying this knowledge, they are able to identify cases of domestic violence or sexual child abuse and can offer help to the victims who rarely reveal the true reasons for a consultation. In their training, medical students have to learn about forensic aspects relevant to their future daily practice. At Hannover Medical School, the course in basic forensics lasts 2 weeks and is mainly taught using talks and seminars, by presenting anonymized images of victims with wound patterns followed by a description of the physics provoking the lesions. To solidify the knowledge, the medical students also attend an autopsy and a forensic postmortem examination in smaller groups of eight plus one tutor. Obviously, ethical problems may arise when integrating real-life cases into student education. Other problems include the repugnance that students may at first experience depending on the presented real cases. Also, the quality of the available cases may differ since no two cases are the same and there is no guarantee to be able to present all relevant findings during a demonstration.

To alleviate these problems, the Institute of Legal Medicine at the Hannover Medical School in collaboration with the Peter L. Reichertz Institute for Medical Informatics developed an e-learning application for medical students that allows a realistic presentation of various relevant forensic findings applicable in group, single, and frontal teaching. The application makes use of an approach integrating augmented reality technology. While virtual reality learning environments can already offer a fearless and forgiving learning atmosphere with the advantages of

U.-V. Albrecht (✉) • M. Behrends • H.K. Matthies • U. von Jan
Hannover Medical School, Peter L. Reichertz Institute for Medical Informatics, Hannover, Germany
e-mail: albrecht.urs-vito@mh-hannover.de; behrends.marianne@mh-hannover.de; matthies.herbert@mh-hannover.de; jan.ute.von@mh-hannover.de

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DOI 10.1007/978-1-4614-3329-3_7,

delivering a repeatable setting with standardized content to interact with and users of mobile learning approaches generally benefit from a location and time-independent learning setting, nevertheless, both approaches lack much of the classic group experience and interaction and the fully sensual experience of real objects as the students themselves are not part of the learning concept.

To combine the benefits of these different approaches, we developed a versatile learning setting called mARble® (mobile augmented reality blended learning environment) which is an application for the iPhone® that enhances the classic learning setting with the advantages of virtual learning environments and aspects of mobile learning. Despite the concept of virtual reality, where an environment is simulated and the participants "have to step away from the environment in which the practice for which they are preparing takes place" (Ellaway 2010), in mARble®, the students step forward and participate as active learners and as learning objects at the same time, interacting in a learning scene in the real world. The key technology to link both worlds is augmented reality (AR).

7.2 Methods

Mobile learning and augmented reality are not new to medical education. On the one hand, mobile computing in general has become an indispensable part of day-to-day life in the workforce with the fastest-growing sales segment belonging to smart phones. The Horizon Report from 2010 sees the Time-to-Adoption Horizon of mobile computing in "<1 year" and states that "the portability of mobile devices such as smart phones and their ability to connect to the Internet almost anywhere makes them ideal as a store of reference materials and learning experiences" (Johnson et al. 2010).

On the other hand, augmented reality is a technology that has been around for years, for example, in gaming applications. Using this technology, a live view of the user's physical surroundings acquired from a camera can be automatically evaluated and augmented by computer-generated content, for example, image overlays, sounds, virtual objects, or other contents, enhancing the user's current perception of reality while allowing virtual interaction with the surroundings. In the past, due to the required computational effort, the use of AR was restricted to a more stationary setting, which imposed a limit concerning its possible areas of application. Thanks to a higher level of sophistication of mobile devices, nowadays, AR applications effortlessly run on mobile devices, for example, smartphones, thus allowing a transfer from a stationary setting to more dynamic application scenarios. Another important factor for reducing the barrier for augmented reality is the high availability of mobile devices as well as their good usability and portability, which opens up an "alluring option for teaching and learning" (Smith 2010). Augmented reality (AR) takes the real world into account and allows live interaction with it.

AR annotates real objects in the physical environment with additional digital information of a complementary virtual world to enhance (augment) the perception of the recipient (Azuma 1997) as is demonstrated in Fig. 7.1: The bridge from the

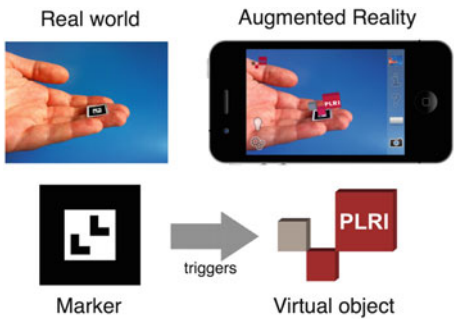

Fig. 7.1 Annotating physical objects of the real world with additional digital information

physical world to the virtual information is a small paper snippet with a characteristic black-and-white pattern printed on it. This so-called marker is registered within the application; corresponding digital information is stored in the application's internal database. While filming the marker, for example, with a mobile device such as an iPhone®, the software interprets the typical pattern as a cue and compares it with the previously registered data. If the system recognizes the pattern, it integrates the corresponding virtual object, for example, the 3D object consisting of three boxes in the presented scenario, into the image displayed on the display of the device in real time—the additional information is now visible to the recipient.

7.3 The Application

As mentioned before, ethical problems may arise when integrating real patients into student courses, especially when victims of crimes such as rape or attempted murder are involved where re-traumatization may be triggered via extensive questioning and examination. With mARble®, the tutor may reproduce such cases from his memory or invent fictive cases by combining markers for the desired set of findings. Thus, the tutor can control the topic and vary the details of the items to be taught to the students, allowing to present cases rarely seen in reality, even if no patient with the corresponding symptoms or findings is available.

The application is able to detect and interpret predefined markers. The marker corresponding to the wound pattern that the student is expected to explore is placed on the body of the student by the tutor. The students get the task to "examine" each other using the iPhone®. Depending on the marker, the desired digital content is presented as a mixed image of the filmed object and the overlaid finding, for example, an entrance wound of a bullet (virtual object) on the arm (real object) as seen in the use case example in Fig. 7.2.

Students can add snapshots of the augmented image to a personal gallery for documentation purposes. In addition, related questions or tasks may be triggered: In the use case example, an entrance wound is detected and a task to "define and describe the characteristics of an entrance wound" is given. For such purposes, mARble® includes a virtual flash card system containing stock phrases and questions, tasks, and related

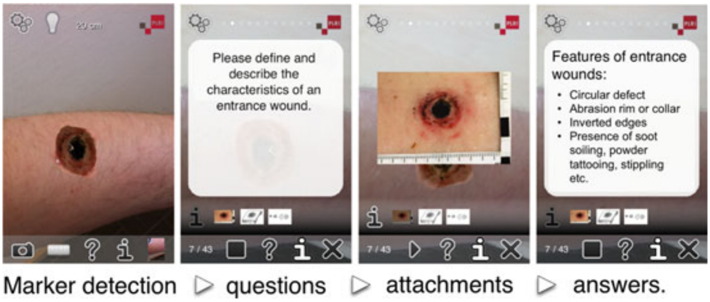

Fig. 7.2 Use case: "mARble®—forensic medicine"

answers plus additional audio, video, or imaging information. The cards are subdivided into topics ("quizzes") and presented on the mobile phone when triggered by the recognition of a related marker via its camera. The cards' content is divided into questions and answers and is written on the virtual front or back side. Using the flash cards, tasks may be assigned and questions posed.

All textual content is linked to audio recorded from an actor explaining the content. It is possible to browse through additional information relevant to the task or question, for example, images, animations, or drawings/illustrations for the case. Depending on the setup (group or single learning, with or without a tutor), previously taken snapshots and findings may later be used in discussions with fellow students or for presentations of the results. For single learning, previously acquired findings can be loaded into the application, and the flash cards are triggered in the same way as during a live recording. The student can then browse through the associated questions and task using an integrated menu. On demand, the answers to each question will be presented. Authoring content is a straightforward process, since mARble® offers an easy approach to authoring and editing content. Its architecture is divided into a presentation engine and content management. While the presentation engine requires deeper programming skills, the content may be comfortably authored in a comprehensive XML scheme without touching the core code of the application. Currently, we are in the process of creating an authoring tool with a drag and drop editor to further simplify the editing step.

7.4 Conclusion

With the "mobile augmented reality blended learning environment (mARble®)," an innovative augmented reality visualization setup is used to combine a traditional learning setting with a mobile learning approach. Content can be added in a simple manner. The tool provides several methods for interaction. Through the presentation of findings on their own skin, students become a learning object while they study. The learning experience becomes a personalized but shareable matter that may enhance interaction in various layers: The confrontation with findings on their own body may lead to a higher personal involvement with the content by provoking emotions and may also trigger an internal dialogue (inner student interaction). Also, discussions about the topic within the learning group (inter-student interaction) and with the tutor may be initiated.

In the literature (e.g., Thomas et al. 2010), various advantages of augmented reality implementations are specified, though little is known about the impact that the merging of the physical and virtual world has on the emotional state of learners within a learning context. How do students react if they see an overlay of the forensic findings on an image of their own body? Does the reaction facilitate the learning process? Will this experience improve the understanding for the patients/victims or will it induce refusal, instead?

Picking up on Hassenzahl's statement that the user experience is an important factor in the design process of products (Hartson et al. 2012; Hassenzahl et al. 2003) in a forthcoming study, we will not only measure the learning success but would also like to identify the pragmatic quality (usability) to achieve the learning goal by using mARble®. Other relevant aspects in this context are how the application stimulates the students through the use of novel and interesting functions, the presentation of the content via innovative interaction and presentation styles (hedonic quality—stimulation), as well as at which level the users identify with the application (hedonic quality—identification). Another question that will need to be addressed is the perception of the application regarding its attractiveness. Hedonic and pragmatic qualities are independent of one another and contribute equally to the rating of attractiveness. In respect to the discussion about theoretic didactical aspects that has emerged in the course of mobile learning developments, the mARble® project can offer a critical contribution. It provokes a thorough inquiry of the learning contexts in which the application is used and makes it clear if the switch "between formal and informal contexts and between individual and social learning" (Looi et al. 2010) can be proven.

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Chapter 8
Location-Based Environments for Formal and Informal Learning: Context-Aware Mobile Learning

Qing Tan, Tzu-Chien Liu, and Martha Burkle

8.1 Introduction

With the rapid development of information and communication technology (ICT), new learning technologies and approaches can be widely found and adapted in learning environments for different forms of learning. In this chapter, we discuss location-based environments for formal, nonformal, and informal learning and focus on mobile learning.

At the dawn of the twenty-first century, mobile devices have been commonly used in people's everyday life. Currently, mobile devices i.e., smartphones have been used not only for voice telecommunication but as powerful data communication tools as well, which are greatly changing our daily lives including learning processes and learning capabilities in the Digital Age. Because of their mobility, portability, and data communication ability, many educational technology researchers, educational professionals, students, and mobile phone users have started to realize the great potential of using mobile devices for learning (Huang et al. 2011; Liu 2007; Liu et al. 2003). Gradually, using a mobile phone to conduct learning is considered an effective way for learning anytime and anywhere. Location-based services are one of the fundamental components in the cellular wireless communication network. Using mobile phones' location awareness into mobile applications has become a new trend, which has attracted great attentions among consumers, technology developers, and academic researchers (Paucher and Turk 2010; Tan et al. 2009; Hermann et al. 2007). Mobile devices allow mobile applications to have strong interactive capabilities with the environment by sensing and reacting to their locations and contexts. Therefore, in a mobile learning setting, learners do use por-

Q. Tan (✉) • M. Burkle
Athabasca University, Athabasca, AB, Canada
qingt@athabascau.ca; martha.burkle@telus.net

T.-C. Liu
National Central University, Taoyuan, Taiwan (R.O.C.)
e-mail: ltc@cc.ncu.edu.tw

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table handheld mobile browsers not only to get learning contents but also to conduct their learning in context-aware and, more specifically (for the purpose of this chapter), in location-based environments.

8.1.1 Location-Based Environments

In this chapter, we focus on mobile devices with built-in GPS receivers, webcams with 3G data, and Wi-Fi communication capabilities (such as iOS, Android, RIM or Windows smartphones, and iPad, Galaxy, Xoom, PlayBook tablets). While people are usually using mobile devices in their daily life, this kind of devices is also used in education as the providers of an appropriate platform to conduct teaching and learning (e.g., Huang et al. 2011; Liu 2007; Liu et al. 2009). Access to learning content through a mobile device has started to become a rapidly developing learning setting. Because of the advanced wireless telecommunication infrastructure, for example, 4G cellular networks and enlarged mobile computational capacities, mobile devices have much stronger capability to implement client–server-based mobile learning applications. Furthermore, the upgraded mobile operating systems and enhanced mobile device middleware and native features may provide learners with authentic learning activities. The wide cellular network coverage, mobility, and portability of mobile devices have set the framework for ubiquitous and asynchronous learning (Chu et al. 2010; El-Bishouty et al. 2007). The unique characteristic of mobile devices is their location awareness that enables the development of mobile learning applications with strong interaction capability. The advanced functions of mobile devices enable mobile learning applications to sense location and to identify learners' learning environments. Thus, in mobile learning settings, learners are able to interact with learning environments by means of mobile learning application's interactive functions.

Within location-based environments for formal, nonformal, and informal learning, real-world objects and scenes are used as learning objects, while learners' mobile devices can sense and react to particular setting or environments. In location-based environments, real-world objects can be integrated and associated with learning content as particular learning objectives, providing pervasive and seamless learning environments. These kinds of environments have the potential to offer tremendous opportunities to support formal and informal learning, especially nonformal learning (a comparison of these two terms will be presented later in this chapter).

In 2006, Yang proposed context-aware ubiquitous learning environments that provided contextual information to support peer-to-peer collaborative learning. He indicated that with context-awareness learning, it can occur in the right place at the right time, when location-based learning environments have been considered (Yang 2006). While mobile devices are used as the location-aware interactive learning devices, location-based environments are considered as learning resources that include contextual information. Learning resources can be provided to dynamically adapt to different learners based on substantial advances in pedagogical theories and knowledge models (Tetchueng et al. 2008; Tan et al. 2011; Burkle 2010). In practice, real-world objects are combined with other learning materials based on learning objectives and then turned into location-based learning contents. Location-based environments associated to learning contents are integrated into "learning management systems (LMS)" and stored in learning repository databases with identification attributes tagged with the location information. When learning takes place, location-based environments associated to learning contents will be retrieved from the LMS using acquired mobile devices' current location information and other contextual information. Then, the information will be landed on learners' mobile devices for the learners to learn or act on accordingly. Many mobile learning applications have been developed and implemented to conduct location-based learning.

From what we have mentioned above, location-based learning environments could facilitate learners' interaction with the real world. Through accessing and experiencing real-world learning objects, learners can connect and associate the information and knowledge learned on books with the actual world to enhance their learning. Location-based environments aim to contextualize learning activities by enabling the learners to interact appropriately with their environment (Patten et al. 2006). Therefore, vivid location-based environments could greatly impact formal, nonformal, and informal learning.

8.1.2 Formal and Informal Learning

In this chapter, we discuss location-based environments for formal and informal learning. Because of the variation of the definition with regard to forms of learning, it is helpful to clarify at this point what we mean by these terms in the context of this chapter.

Ainnsworth and Eaton outlined and summarized notions of formal, nonformal, and informal learning in the framework of learning in the sciences (Ainnisworth & Eaton, 2010). These practices are described as:

- Formal learning—A type of learning that is intentional, organized, and structured. Institutions usually arrange formal learning opportunities. Often, a curriculum guides this type of learning.
- Nonformal learning—An institution may or may not arrange this type of learning intentionally. It takes place outside the formal learning system but is usually organized in some way, even if it is loosely organized. This kind of learning does not follow a formal accreditation processes.
- Informal learning—This type of learning is never organized. Rather than being guided by a rigid curriculum, it is often thought of as experiential and spontaneous.

Koole (2009) builds a model to analyze the impact of mobile technologies for both formal and informal learning processes. In her FRAME—Framework for the Rational Analysis of Mobile Education—model, Koole describes the role of mobile technologies in the provision of a learning platform to support formal access to learning (content provided by a higher education institution) and informal learning (knowledge exchange between technology users). Formal learning addresses knowledge, memory, and context, while informal learning deals with learner's emotions and motivations.

In the context of this chapter, we focus on location-based environments for formal and informal learning. In order to be precise with the type of learning analyzed in our research, we have combined both terms as understood by Ainnsworth and Eaton into one learning type: formal learning and alter informal learning. Hence, the following discussion in this chapter will refer to the definition of learning type as:

- Formal learning: This type of learning takes place inside or outside the school environment. It is conducted within teacher–student relationships. It is arranged by education institutions and guided by a curriculum. It aims to achieve a particular course's learning objectives.
- Informal learning: The type of learning that is never organized but still intentional. Rather than being guided by a rigid curriculum, it is often built on experience, and it is always spontaneous. It does serve for learner's overall learning objectives.

In the following section, we will explore location-based environments in the two learning forms. Next, we will introduce research related to location-based environment for learning. Then, we will introduce mobile applications and research for location-based environments. Finally, we will conclude this chapter on the location-based environments for formal and informal learning topic.

8.2 Location-Based Environments for Learning

Location-based environments for learning have become a hot topic with the significant growth of mobile learning devices in recent years in context-aware ubiquitous learning. Since mobile learning can take place at anytime and in anywhere, there is an advantage to integrate the real-world objects into learning contents. With regard to location-based learning environments, we need to examine the differences between formal and informal learning in practices to identify their advantages and limitations.

8.2.1 Location-Based Environments for Formal Learning

It is not very common to include real-world objects and scenes—such as historic places, geographically and geologically interesting spots, interesting architectures, landmark buildings, and museums—into a course delivery framework as learning objects. Learning with location-based environments can be found through arranged field trips, outdoor education, environmental studies, and field-worker training. It is important to know that in this framework, learning is still guided by curriculum, and it is conducted by the instructor or teacher to fulfill the course learning objectives. In this type of learning, that is, formal learning, location-based environments are used as learning objects. Usually, teachers assign learning tasks associated with location-based environments to students and provide them learning materials or tools as well as instructional documents to directly or indirectly lead them to complete the learning tasks on-site or to work on the tasks on their own. In this case, students' learning achievements are often evaluated through assignments or reports or presentations or examination.

In this chapter, location-based mobile learning is considered an organized and structured method of learning internal or external to the formal learning environment. It complements classroom learning by engaging students in location-based environments. Learning contents associated with the location-based environment are predeveloped and stored in the learning contents repository so that students can retrieve them through mobile devices when they are in the location. Many researchers have demonstrated that mobile learning has the great advantage of incorporating location-based environments for learning (Peng et al. 2009; Chu et al. 2008).

With advanced wireless telecommunication networks and mobile technologies, the integration of location-based environments for formal learning through mobile devices has become much more effective and efficient. Applying mobile device's location-awareness features, context-aware mobile learning has unique and remarkable strength in implementing location-based environments for formal learning.

In recent years, there have been several interesting and innovative location-based applications, such as location-based grouping—Mobile Virtual Campus (Tan et al. 2010), Environmental Detectives (Klopfer and Squire 2008), Butterfly Watching (Chen et al. 2005), CAERUS (Naismith et al. 2005), Ambient Wood (Rogers et al. 2004), Savannah (Facer et al. 2004), and Riot! 1831(Reid et al. 2004)—that could be used in the context of formal and/or informal learning environments.

As an example of using mobile learning applications in location-based environments for formal learning, we introduce the Mobile Virtual Campus system that is used to develop mobile-technology-guided field trip activities for the Athabasca University *Geography 266* course for distance education in physical geography. Figure 8.1 shows the conceptual architecture of the field trip.

The course instructor describes the content of the course in her own words:

> In this course, students study the internal structure of the Earth, the rocks that compose it and the forces within the Earth that act to deform both its internal and surface structural composition, thus creating relief. Students also learn about the denudation processes that unceasingly act at the Earth's surface to shape landforms and reduce relief, thus covering the topics of weathering, mass movement, erosion, transportation, and deposition by the geomorphic agents of water, waves, wind, and ice. The fieldtrip consists of a visit to the area around the Crowsnest River Valley and Turtle Mountain in the Canadian Rockies of southwest Alberta, famous for being the site of the deadliest rockslide in Canadian history. This event is known as the Frank Slide because it destroyed the southern end of the town of Frank in 1903. The fieldtrip is expected to be undertaken by students, individually or as a

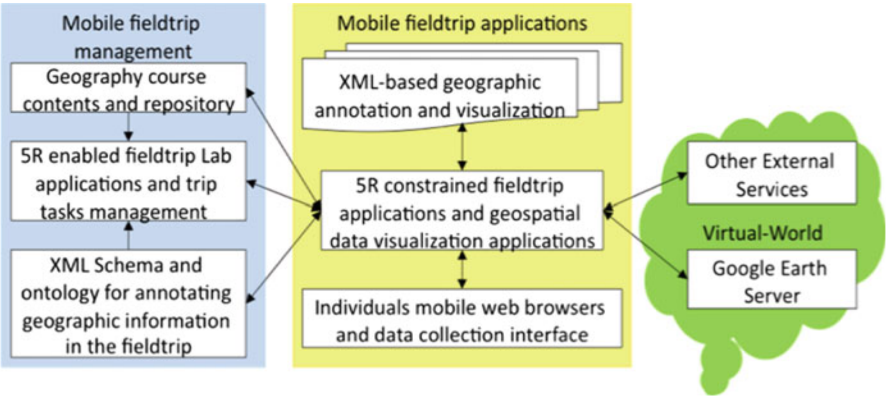

Fig. 8.1 The conceptual architecture of the location-based mobile field trip (Tan et al. 2011)

group, in the absence of direct supervision from an assigned instructor. Instead, it is facilitated by a mobile device that acts as a guide by drawing students' attention to geographical features of interest. The mobile device also delivers a list of tasks and reflective questions to students as they undertake the field trip. Finally, it enables data collection and annotation in the field (Pivot 2012).

8.2.2 Location-Based Environments for Informal Learning

In contrast to formal learning, location-based environments for informal learning are usually found as casual and self-motivated learning. Learners can learn with location-based environments without waiting to receive instructions from the teacher or course guide. Informal learning with location-based environments could happen in the context of experience, and even if it is spontaneous, it is still intentional. It does serve for the learner's overall learning objective.

Mobile applications can provide learners great interactive ability with location-based environments for informal learning through mobile devices. Mobile learners can learn anytime and anywhere by using location-based environments in their everyday life. Many fascinating mobile applications can be employed to assist learners for informal learning. Some examples of these are iCollaborator, an iPhone application that was developed at Athabasca University to provide multimedia mobile meeting and interactive virtual whiteboard in which participants can effectively communicate and exchange ideas in a real-time manner with location-aware aspects (Lo and Tan 2010). Figure 8.2 shows screen shots from iCollaborator. With the iCollaborator, learners can have real-time communication and exchange ideas with others to assist their learning from their everyday life.

Below is a quote from an iCollaborator user:

> As a scenario Jason, a visiting student learns Chinese in China. When he is in a Chinese restaurant, he may run iCollaborator on his iPhone to communicate and share the menu in

Fig. 8.2 The iCollaborator's interfaces and whiteboard (Lo and Tan 2010)

Chinese through the whiteboard with his buddy, Wei Tao to ask him to help for his order. At the same time, he could learn Chinese on the menu, which eventually helps his Chinese learning.

Another example of mobile application for informal learning is Word Lens. This application translates instantly printed words from one language to another. It can be used as a great tool for language learning in location-based environments (Quest Visual Inc. 2010). There are also some location-based mobile applications that enable informal learning in location-based environments, such as "Geocaching" software and location-based games.

Indeed, using location awareness of mobile devices gives mobile learning applications a distinguishing ability for facilitating mobile learning, either formal or informal, and to interact with the location-based environments. Enabling the context-aware feature makes mobile devices stand out as a learning media and motivates the development and innovation. It provides tremendous opportunities for integrating location-based environments for formal and informal learning.

8.3 Location-Based Environments Issues and Opportunities

The integration of location-based environments into the context-aware mobile learning systems opens great opportunities for teaching, learning, learning content management and delivery, and educational administration. At the same time, many theoretic, pedagogical, and technical issues and challenges need to be examined and solved in order to successfully implement location-based environments for learning. A research framework was proposed for research on location-based adaptive mobile learning by Tan et al. 2009. As the research on this issue progresses, research topics and issues are respectively categorized into four aspects: technology, application, pedagogy, and education.

8.3.1 Technology Issues

Location-based environments for learning are based on the advancement of technologies, especially mobile technology and location-based technologies. The research issues and topics in the technology layer focus on studying the technical solutions to find the optimal answer for the integration of location-based environments for learning.

1. Mobile device issues:
   (a) *Mobile computing:* how to optimally use the mobile device's computation capacity and to utilize mobile devices' native hardware and software functionalities
   (b) Human–machine interaction: how to identify effective human–mobile device interface and to apply the cutting-edge mobile technologies to enhance the interaction among humans, mobile devices, and location-based environments
2. Location-based environment issues:
   (a) *Location-based technologies* to study and apply positioning solutions for indoor and outdoor location identification and navigation
   (b) *Wireless sensor network and sensors:* how to tag the real-world objects indoor and outdoor and to study effective sensors and sensory technology-based mobile devices' interactive capacity
3. Learning management system's server application issues:
   (a) *Location awareness and contextual information* to study algorithms and system architectures for location-based learning management systems to effectively process acquired contextual information and to provide location-based adaptive learning contents
   (b) *Artificial intelligence and natural language processing:* how to use AI to design and build more intelligence in learning systems to continuously upgrade and calibrate location information for improving positioning accuracy and efficiency and system performances
   (c) *Data mining and data analytics* to track learners' learning behaviors and to build learners' profile for enhancing personalized learning
   (d) *Fuzzy logic and set theory* to quantify the contextual information and descriptive measurements for calculation in order for the learning management systems to be able to automatically make decisions and evaluations
   (e) *Imaging processing* to effectively process images captured by mobile devices that will allow interaction with location-based environments via mobile devices' built-in webcams
4. Learning management system infrastructure issues:
   (a) *Cloud computing* to study and develop robust networking infrastructure, learning application platforms, and learning application software for easily and effectively accessing learning resources and to develop CASS (Computer-Assisted Social Services) learning content delivery model
   (b) *Robot telepresence* to study and develop online remote labs and to allow online learners to interact with location-based lab environments through robot avatars

8.3.2 Application Issues

Location-based mobile learning applications are the means of utilizing location-based environments for learning. The location awareness of mobile devices offers great opportunities to develop innovative and effective location-based applications to facilitate and enhance location-based learning and teaching. The main goals of the location-based applications are to provide collaborative, adaptive, and interactive learning platforms.

- *Location-based collaboration* to study and develop mobile applications that enable learners to learn collaboratively through location-based environments
- *Location-based adaptation* to study and develop mobile applications that are able to provide learning content adapted to contextual information, especially location information corresponding to location-based environments
- *Location-based instruction* to study and develop mobile applications that allow instructors to give lectures or instructions according to location-based environments
- *Location-based assignment and problem solving* to study and develop mobile applications that are capable of allocating location-based assignments and to ensure that problems are solved in the designated locations
- *Location-based augmented reality* to study and develop mobile augmented reality applications that enable learners to use the augmented reality technique to interact with location-based environments
- *Location-based learning content delivery* to study and develop mobile applications that can sense and react to location-based environments and deliver learning contents based on the location-based environment

8.3.3 Pedagogy Issues

Pedagogy issues in location-based environments for learning address the transferring of educational needs, ideas, methodologies, and practices into technological solutions for design and development of learning applications. By studying these issues, it aims to assist technological solution providers to create and develop applicable and helpful learning applications for educational use.

- *Location-based environments in course development* to study how to integrate these into course design in order to make the integration better serve for the entire learning objectives and to ensure the integration to be implementable and practical in learning
- *Implementation of location-based environments in different forms of learning* to study implementation of location-based environments in different learning forms and to explore the best practice based on difference between educational methodologies and environments and to identify differences in applying location-based environments in formal and informal learning

8.3.4 Education Issues

The final goal of implementing location-based environments for learning is to enhance teaching and learning. Therefore, we need to evaluate their effectiveness and to identify the best practice of location-based environments for learning from an educational point of view. We also need to use educational research methodology to analyze the learners' behaviors and patterns in location-based environments, to understand the strength and weaknesses of location-based environments for learning in order to provide possible solutions and suggestions. It is therefore very important to study the technology impact and explore the trends associated with location-based environments for learning.

- *Location-based technologies for learning* to study the rationale behind location-based technologies for learning and the effectiveness and application areas of location-based technologies for learning
- *Effectiveness of location-based environments: strength and weakness* to study the effectiveness and to identify the strong possibilities and challenges of location-based environments for learning from technology and pedagogy perspectives
- *Learners' behaviors in location-based environments* to study mobile learners' activities and actions and to find the learning patterns in order to build learning models and to develop effective learning systems

Despite many challenges and unsolved issues of location-based environments for learning, there are great opportunities in applying location-based technologies to create innovative and effective learning applications for academic researchers, application developers, technical educational solution providers, as well as teachers and students. Through advanced technological means, the effective implementation of location-based environments for learning has become a possibility and a reality in education.

8.4 Location-Based Mobile Applications for Learning

In this section, we will present and discuss mobile learning applications that have integrated location-based environments as contextual information. From the literature review, we found that there are some recent research papers introducing location-based environments for learning, such as Clough's "Geolearners: Location-based informal learning with mobile and social technologies" (Clough 2010) (Clough *et al.* 2009).

Elizabeth Brown edited a report in which a collection of contextual and location-based mobile learning researches and applications is presented (Brown 2011). Later in this section, we will introduce location-based mobile learning academic researches and application system development that we have directly involved to address the research, development, and implementation of location-based environments for learning.

8.4.1 Location-Based 5R (Right Time, Right Location, Right Device, Right Content, Right Learner) Adaptation Framework

With the goal of providing a solution and a standard structure for implementing wider-ranging adaptation for location-based environments for mobile learning, this research is still ongoing at Athabasca University (Tan et al. 2011).

The 5R adaptation concept for location-based mobile learning is stated as "at the right time, in the right location, through the right device, providing the right contents to the right learner." This adaptation concept aims to enhance learning in location-based learning environments by taking the factors of learner, location, time, and mobile devices into consideration. The 5R adaptation framework imposes the adaptation of constraints through the 5R adaptation mechanism to generate the 5R adaptive learning contents. The 5R constraints can be semantically presented and accessed during the automatic decision-making process for generating personalized learning content "filter." The framework provides learners with adaptive learning contents based on their learning profiles and learning styles, additionally to adapt to learners' current locations, times, and devices. Figure 8.3 illustrates the concept of the 5R adaptation framework.

The 5 "Rs" that integrate the model and their dynamics interrelations are crucial in the definition of the learner's system and in the provision of location-based environments. These interrelations are explained by the authors as follows:

- *The right time:* The time in the adaptation framework indicates two factors, the date–time and the learning progress sequence. The learning contents associated with the location-based environments are with date–time constraint that reflects time and date when the location-based environments are accessible, such as a lab, library, or museum. Learner's learning progress sequence is also considered as a time factor. Since mobile learning takes place anytime, by including the time constraint, the mobile learning system is able to provide the learning contents at the right time.
- *The right location:* The location in the adaptation framework indicates a learner's current geographic location. Location awareness of the learner's mobile device is used to sense the learner's current geographic location. When the mobile learner is physically at or near particular location-based environment, the learner could be assigned to conduct location-based learning activities to complete learning tasks at the location. Since mobile learning takes place anywhere, by including the location constraint, the mobile learning system can provide the learning contents in the right location. Location-based environments for learning have the unique ability to provide the location adaptation.
- *The right device:* The device in the adaptation framework refers to the learner's mobile device that is used to conduct mobile learning. The device adaptation is also the distinctive feature of mobile learning compared with other computer-assisted learning scenarios. From its nature, mobile devices are heterogeneous,

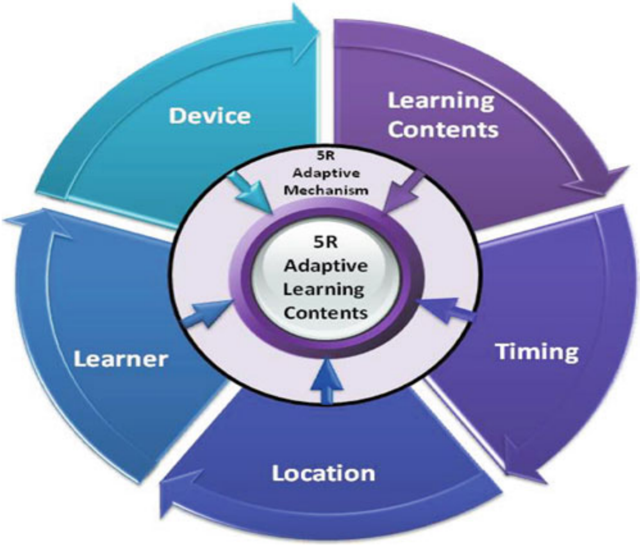

Fig. 8.3 The 5R adaptation framework concept diagram (Tan et al. 2011)

and therefore, it is essential to provide the right format of learning contents to the right mobile device. The device adaptation can provide learners the best possible learning experience in terms of the use of a particular mobile device.

- *The right content:* The content in the adaptation framework includes learning objects, learning activities, and leaning instructional materials. Learning content can be constructed or retrieved based on the learning objectives, pedagogy, and academic structure. The right learning content will suite the learner's learning objectives and learning style at any particular time and in association with location and the particular mobile device used.
- *The right learner:* The learner in the adaptation framework is the individual who conducts learning through a mobile device in the location-based learning environment. A learner's learning profile and learning style have been taken into account in order for the learning system to identify the learner's individuality and personality compared to that of other learners. The learner's profile information contains the learner's learning objectives, learning progress, learning behaviors, and learning assessment results. The right learner means that the learner receives the learning contents provided by the learning management system matching with the learner's learning profile information.

The learning system is required to track down where the learner is, and which location-based environments are near to the learner, and if they are accessible at the time where the learner is located in that particular environment. Thus, the system has the capability to automatically alert the learner when the learner is approaching to or is at a particular location and then to provide the learner the right learning contents. Within the 5R adaptation framework, the learning system provides

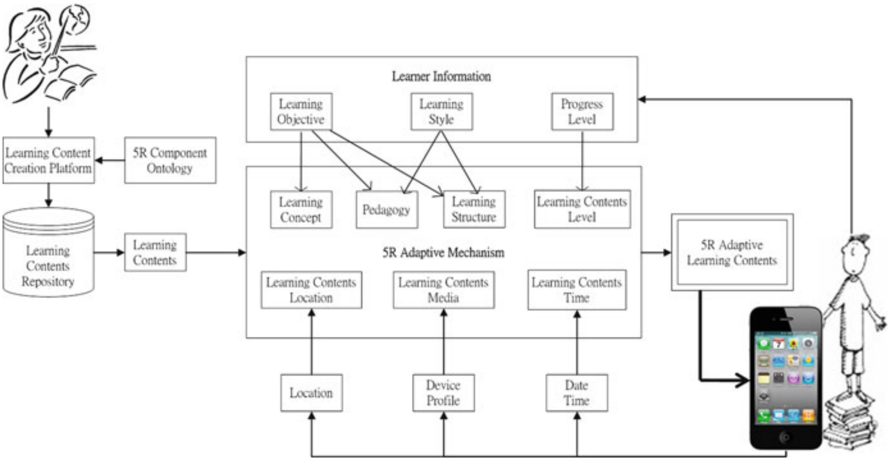

Fig. 8.4 The 5R adaptation mobile learning system architecture (Tan et al. 2011)

adaptive learning contents that not only have personalized adaptation but also have location, time, and device adaptation. Figure 8.4 describes the dynamic process of the 5R model interaction.

Location-based learning application system architecture is proposed based on the 5R adaptation framework shown in Fig. 8.4. The 5R adaptive mechanism is the core engine to process the adaptation constrains and to generate the 5R adaptive learning contents for learners. In the system architecture, a location-based learning content creation platform is designed for instructors or content developers to build and integrate location-based learning content. The platform is designed based on the 5R input ontology that ensures all the learning content developed to be used by the 5R adaptation mechanism. Moreover, the 5R adaptation mechanism could be viewed as a meta-architecture for the application system architecture in which different design or implementation strategies could be applied as long as the architecture and functions of mobile learning application comply with the 5R adaptation constraints and key relation models.

8.4.2 Mobile Natural-Science Learning

The research on mobile natural-science learning was conducted in Taiwan to study designing mobile natural-science learning activities that rest on the 5E Learning Cycle. The project was built on the examination of the effects of learning activities on students' performances when learning about aquatic plants and exploring students' perceptions toward these learning activities (Liu et al. 2009). The study identifies two positive effects in the learning process: students' engaging in "mobile-technology-supported" *observation* during their scientific inquiry and students' engaging in "mobile-technology-supported" *manipulation* during their scientific inquiry. The 5E Learning Cycle phases are described as the follows:

- *Engagement phase (E1):* The main task of this phase for the teacher is to assess students' prior knowledge and motivate the students to engage in learning a new concept. With the teacher's assistance, students are also encouraged to connect their prior knowledge to present learning and to organize their thoughts about the learning outcomes of current activities.
- *Exploration phase (E2):* The main task of this phase for the teacher is to provide students with a common base of activities that reflect concepts, processes, and skills. In this phase, students are encouraged to complete activities by using their prior knowledge to generate new ideas, to explore questions, and to conduct a preliminary investigation.
- *Explanation phase (E3):* The main task of this phase for the teacher is to let students focus on specific aspects of their "engagement" and "exploration" experiences and to provide students with the opportunities to demonstrate their understanding or skills. The teacher can assist the students to have deeper understanding of a specific concept by using direct instruction and guidance.
- *Elaboration phase (E4):* The main task of this phase for the teacher is to challenge and extend students' conceptual understanding and skills. Through the above three phases, students are expected to develop broader and deeper understanding and skills.
- *Evaluation phase (E5):* The main task of this phase for the teacher is to evaluate students' progress toward achieving the instructional goals. Students are encouraged to try to assess their understanding and abilities.

This study took place in an elementary school in Taiwan, which had been constructing an ecological pool for years. The school planned to establish a location-based mobile learning environment devoted to natural-science instruction on aquatic plants. In order to advance students' learning of aquatic plants, the project was designed, developed, and implemented including mobile learning activities. In order to examine the effects of learning activities and possible factors underlying these effects, the researchers collected and analyzed data on students' performances, perspectives, reflections, and opinions about the instruction.

The location-based mobile learning environment consisted of two major components: one of them was the Ecological Pool website and the other was the tablet mobile device used by each participating student. Such a learning environment enabled the teacher and the students to use the resources of the website in any place (such as the ecological pool and the laboratory) at the school via the students' tablet mobile devices. The "Ecological Pool" website was developed in order to provide an easy delivery platform, and all the information on it echoed the instructional requests from science teachers at the school. These resources provided hands-on problem solving as well as reinforced concepts and understanding. They were used for class instruction, outdoor inquiry, lab activities, individual or small group study, and assessment, in a ready-made format for downloading.

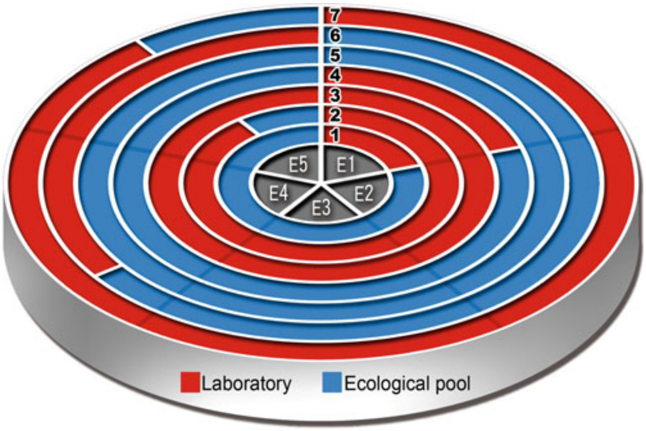

Fig. 8.5 The implementation of a mobile learning activity (Liu et al. 2009, p. 350)

Finally, in this study, seven learning activities were designed and developed based on teachers' instructional requirements, the tenets of the 5E Learning Cycle, and the school's existing learning resources. Figure 8.5 shows the implementation process of these seven learning activities. The five phases of the 5E Learning Cycle served as the foundations of the seven activities. The study involved the location-based environment, the pool, the learning devices, wireless connections, and the Ecological Pool website. At all times, and without constraints of time or location, the seven learning activities were executable and implemented.

Figure 8.6 displays specifically the implementation of activity six, which best demonstrates the use of the 5E Learning Cycle within location-based mobile learning environments. Figure 8.5 also explains the 5E Learning Cycle phases and the tasks for the teacher and the students in each phase. The instructional goals were that students should learn the specific forms and the specific habitats of the "emergent-type" aquatic plants. Besides individual learning, students also had the opportunities to conduct an inquiry with their team members. For instance, in the "Elaboration" phase of activity six, students worked in groups to complete their activity sheets via observation, the reading of materials on the website, the conduction of experiments, and sharing findings.

Finally, students were asked to browse the Ecological Pool website and to familiarize themselves with the 13 emergent-type aquatic plants. Once this activity was completed, students filled out the pre-activity sheet online. The teacher helped them connect their past and present knowledge. Students carried out their preliminary investigation of "emergent-type" aquatic plants by filling out the activity sheet via on-site observation at location-based environment (i.e., the ecological pool) and/or searched for information on the website. The teacher guided the discussion on the activity sheet and helped students locate the exact spots of these 13 emergent-type aquatic plants. Then, students refined their activity sheets through on-site observation at the pool and accessed the website. Students were encouraged to demonstrate and explained their understanding of the "emergent-type" aquatic plants.

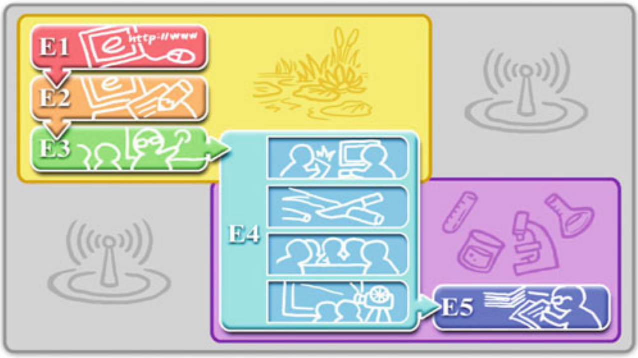

Fig. 8.6 Flow chart of the sixth learning activity (Liu et al. 2009, p. 350)

This research case study demonstrates the efficiency of using location-based environment for learning. It concludes that integrating location-based environments is an effective approach for learning. It also produced a useful guide for educational practitioners concerned with the potentials of applying location-based environment for mobile learning in school settings.

8.4.3 Location-Based Mobile Virtual Campus

In 2009, a group of researchers at the University of Athabasca in Edmonton, Canada, developed a collaborative mobile learning system called "Mobile Virtual Campus (MVC)." The campus model provided an interactive platform for online mobile learners by using the location awareness and other built-in sensory components built within mobile devices' capabilities (Tan et al. 2010). On the virtual platform, mobile learners can learn collaboratively and interactively either at a distance or face-to-face using mobile learning settings provided by the device. Furthermore, mobile learners can share learning experiences with their peers just like in a traditional classroom.

The core of the Mobile Virtual Campus application system is the location-based dynamic grouping algorithm that enables learners to be grouped primarily based on their location closeness. In addition, the grouping algorithm also takes learning factors as the grouping criteria, such as learners' learning profile, learning styles, and learning interests. The algorithm creates the default-learning group for the learners with similar learning profile and style in order to benefit them from the interaction in situations where collaborative learning is necessary. The grouping algorithm has also the option of using a learner's learning interest as the sole learning criteria in addition to the learner's location for grouping. The algorithm can create the interest-learning group for learners with similar interests to facilitate their learning in pursuing learning objectives. Furthermore, the algorithm can create a group based only on the learners' locations by social group.

The location-based dynamic grouping algorithm is a learner-centric algorithm used in order to protect online mobile learners' privacy. A learner has to initialize the grouping request. Without the request, the learner's location and other data will not be used by the algorithm and will not be shared with other learners. It is the learner's decision to join or not the group suggested by the algorithm or which group to join. Furthermore, the learner can quit grouping at anytime. The grouping algorithm is a dynamic process for the following reasons. The algorithm provides online mobile learners with instant grouping options, and the learners of an existing group may vary (i.e., learners in a group come and go according to their will). The learner's geographical location may be different to the grouping algorithm each time the learner requests for grouping.

The Mobile Virtual Campus model includes collaborative mobile learning groups that are created by the location-based dynamic grouping algorithm. Learners in a group share the closeness in geographical location and have similarity in terms of learning profile and learning styles, and/or learning interests. The MVC therefore extends the virtual campus concept into a mobile learning framework by exploiting the unique location-awareness feature of mobile devices. Figure 8.7 shows the MVC application system architecture. The MVC application system has a lot of features and functions for learning; it especially enables location-based environments for learning. While MVC provides learners grouping the opportunity to participate, it also allows instructors or learning content developers to integrate location-based environments into the system to provide learners location-based learning contents. The location-based learning objects associated with the grouping geographic coordinates will be then automatically presented to the students who can access, experience, and study the location-based learning objects within the grouping distance range together. Some MVC mobile application (iPhone version) interfaces are shown in Fig. 8.8, in which the last two shots show a group associated with location-based environments marking with numbers 1, 2, and 3 on the map.

8.4.4 Location-Based Mobile Augmented Reality Systems

Augmented reality allows the user to see virtual objects superimposed upon or merged with objects from the real world. Multi-Object Oriented Augmented Reality (MOOAR) systems for location-based environments for adaptive mobile learning (Chang and Tan 2010) are one of the ongoing research projects at Athabasca University. Mobile augmented reality systems provide the individual learner with intuitive human–computer interfaces and personalized and location-based adaptive learning contents while carrying the advantages of flexibility, portability, mobility, and context-aware instructions. Individual learners can then interact with location-based environments.

The Multi-Object Oriented Augmented Reality (MOOAR) system is a client–server-based mobile application. The server site application includes an adaptive module to implement the 5R adaptation, *at the right time, in the right location, through the right device, providing the right contents to the right learner*. For this mobile augmented reality approach, the key technical challenge is to identify the

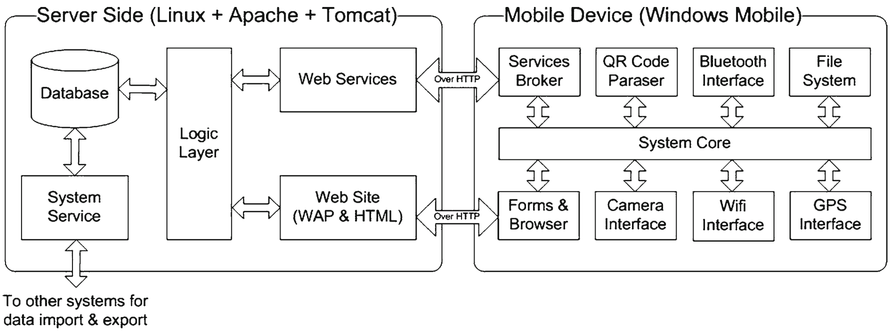

Fig. 8.7 The MVC application system architecture (Tan et al. 2010).

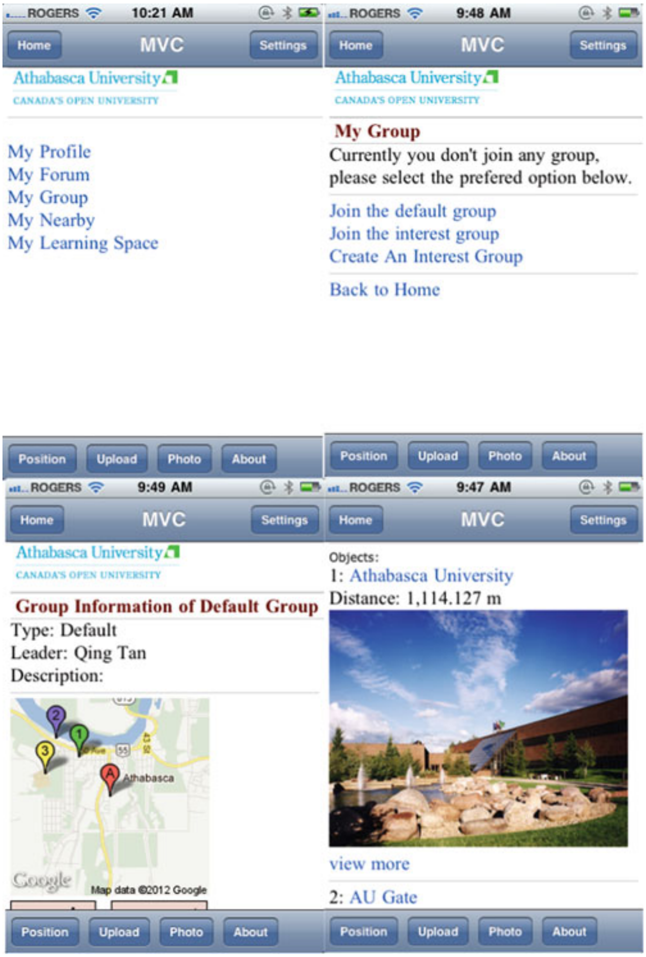

Fig. 8.8 Screenshots of the MVC mobile application interfaces

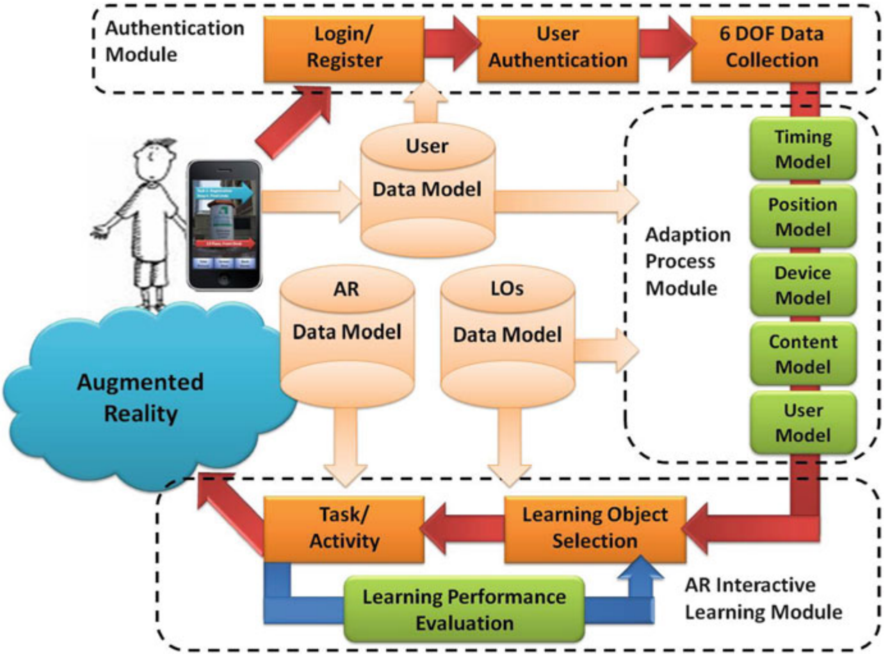

Fig. 8.9 Multi-Object Oriented Augmented Reality system architecture (Chang and Tan 2010)

real-world object or scene that the mobile camera is pointing at. Researchers in this project use GPS mobile device receivers, accelerators, and compasses to obtain geographic coordinates of the mobile device's current location and the camera orientation (i.e., the 6DOF information of the mobile device). The development of an algorithm to identify the relative position and orientation between the mobile camera and real-world object or scene is in the process of being developed by the research team. If there is a match found, the corresponding location-based learning content associated with the location-based environment will be rendered on the mobile device screen superimposing on the real-world object or scene.

The Multi-Object Oriented Augmented Reality (MOOAR) system architecture is shown in Fig. 8.9. The mock mobile device's display in implementing MOOAR system is illustrated in Fig. 8.10.

8.5 Conclusions and Future Research

In this chapter, we have discussed how context-aware mobile learning systems facilitate location-based environments for formal and informal learning. Context-aware mobile learning is indeed an efficient approach to integrate location-based environments as learning content into courses for formal learning as well as informal learn-

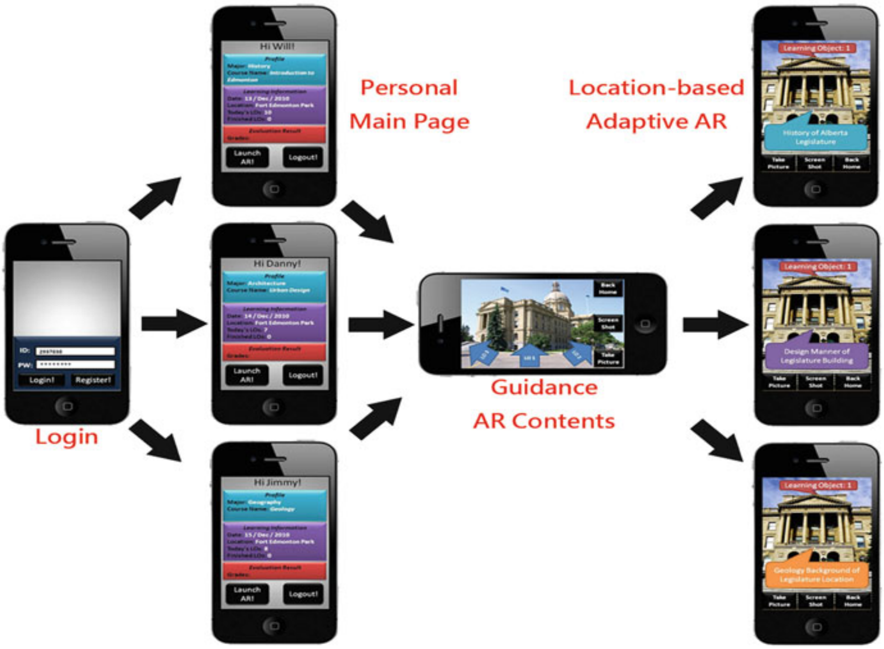

Fig. 8.10 The mock mobile device's display (Chang and Tan 2010)

ing. Usually, courses are complemented with field trips or other location-based learning activities to study real-world objects and scenes. Informal learning happens experientially and spontaneously through interacting with location-based environments in learners' daily life. Applying advanced location-based technologies to mobile devices, and mobile communication infrastructure into location-based mobile learning, is still in a very early stage. Nevertheless, we believe that it opens great opportunities in terms of providing effective and innovative learning means to engage learners interacting with location-based learning environments.

We are also aware of the fact that the application of advanced location-based technologies to mobile devices brings also many challenges in terms of learning technologies, pedagogy, and learning administration. By implementing location-based environments for learning through context-aware mobile learning, students out of their traditional classroom will be able to interact with learning objects from the real world and to connect their knowledge to it, which enlarges and extends their learning to anywhere and at anytime. Further research will need to analyze the impact of context-aware mobile learning systems in students' learning and the training needed by faculty to properly use new mobile devices as they provide access to learning objects inside and outside the classroom space.

We are aware of the great learning possibilities that context-aware mobile technologies can provide for students and instructors, but we also know the huge challenges that the use of this kind of technologies may bring to education institutions currently and in the near future. These challenges will be related not only to the technology itself but also to the development of policies to support and regulate learning innovation, to the provision of faculty training to adopt these kinds of technologies, and to the establishment of research units that will develop, observe, and adapt the use of these technologies for the better improvement of learning.

Research and development in this field has already attracted great attention by researchers and faculty members in this area, application developers, and educational professionals in recent years. In the coming years, it will promote location-based environments for formal and informal learning for the twenty-first-century learner.

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Part III
Social Web Technologies for New Knowledge Representation, Retrieval, Creation and Sharing in Informal and Formal Educational Settings

Chapter 9
Everything Matters: Development of Cross-Curricular Competences in Engineering Through Web 2.0 Social Objects

Mercedes Rico, Julian Coppens, Paula Ferreira, Héctor Sánchez, and J. Enrique Agudo

9.1 Introduction

Following the Bologna reforms, higher education curricular designs are often competence based. According to Perrenoud and Andreu (2007), competences can be defined as the capacity to use the necessary resources to respond efficiently to a complex situation within a given context. In other words, competence involves selecting the most appropriate skills to solve a problem using adequate selection criteria and judgment.

According to the Organisation for Economic Co-operation and Development (OECD 2011), all human achievement requires the use of competences in order to perform several skills. Whereas a skill is an ability acquired through practice and training, competences are the ability to meet complex demands by mobilizing psychological and cognitive resources (including skills and attitudes) in a particular context (Rychen and Salganik 2000). In educational contexts, competences are a set of knowledge, skills, and attitudes that describe the learning outcomes of an educational program. The European Union has developed a set of key competences considered essential in an information society in order to guarantee a more flexible labor force and allow quicker adaption to constant changes in an increasingly interconnected world.

Competences can be classified into two types:

- *Technical or specific competences* are related to technical skills needed to perform the activity or job related to the qualification. They change more frequently than cross-curricular competences. They can be classified into conceptual, procedural, and professional.

M. Rico (✉) • J. Coppens • P. Ferreira • H. Sánchez • J.E. Agudo
University of Extremadura, Badajoz, Spain
e-mail: mricogar@unex.es; julianc@unex.es; paulabrfer@unex.es; sasah@unex.es; jeagudo@unex.es

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- *Cross-curricular competences* (also termed horizontal or general competences) are those which, although not related directly to technical knowledge, are required in order to apply technical skills to a variety of roles and contexts.

Cross-curricular competences, common to most professions and transferable between different activities, sectors, or organizations, can be divided into instrumental, interpersonal, and systemic competences.

Among the instrumental competences are cognitive, methodological, technical, and linguistic abilities necessary for knowledge comprehension, construction, and management, as well as to critique information required for professional practices, methods, procedures, and techniques. Interpersonal competences are concerned with relationship skills and social integration and the application of those skills within specific and multidisciplinary teams, whereas systematic competences are skills and abilities which allow individuals to see how the parts of a whole are related and interact.

Competences are also a major factor in innovation and competitiveness, in that they contribute to the motivation and satisfaction of employees and thus productivity.

Based on the before mentioned premises, our work has a twofold objective. First of all, it entails the identification of some of the most important generic skills/competences in the area of engineering, more specifically in computer engineering. Second (and based on the first objective), we will develop a framework to integrate these skills/competences into the classroom using Web 2.0 tools, environments, and platforms.

Our work will be developed as follows: first, we will define competences and state their importance not only because they are required by the European Area of Higher Education but also because they establish skills the student has to acquire in order to *perform well*, both at work and at an individual and social level, as an active European citizen; then, we will focus on Web 2.0 and its variety of tools, specially bearing in mind *their* collaborative and constructivist capabilities to develop the types of cross-curricular competences our work is interested in; third, we will present our study, defining the cross-curricular competences of computer science degree, establishing their scope and describing our proposed activities to test and evaluate their acquisition, and finally, we will present our conclusions on the development of activities to enhance the acquisition of cross-curricular competences through Web 2.0 tools.

9.2 Competences

Today's society calls for new competences which require the mastery of skills as well as specific abilities. Therefore, the European Area of Higher Education has responded to various studies from the 1990s which, through extensive surveys of graduates and employers, have demonstrated the importance of so-called generic skills in the academic and professional roles occupied by graduates. The resulting higher education reforms created new academic and professional profiles that incorporate the requirement that students be trained not only in specific skills but also in generic skills and required that these skills be evaluated.

The concept of competence has been defined as the ability to respond to demands and carry out tasks adequately (OECD 2011). It should be understood from a holistic perspective; that is, the ability to respond successfully to professional training or research does not rely exclusively on memory but on the ability to apply, adapt, explain, develop, share, and manage knowledge. Therefore, university education in the new context is no longer focused exclusively on concepts, theories, and paradigms but must also incorporate teaching methods that promote the attainment of competences related to employment requirements. The acquisition of competences becomes central to learning.

The Tuning Project (González and Wagenaar 2003) was an important basis for the transformation of the university curriculum as part of the European convergence in higher education reforms. This project classifies generic and specific competences:

- Specific competences cover the professional profile of each degree; therefore, they vary from one profession to another, are specific to the curriculum of each degree, and form the basis of effective and efficient development of knowledge, attitudes, and interest related to the professional field covered.
- Generic competences are cross-curricular skills common to all degree programs and developed in relation to three key criteria (Rychen and Salganik 2003); they contribute to high-value results both personally and socially, are applicable to a wide range of relevant contexts and areas, and are important for all people to successfully meet a variety of complex, lifelong needs.

One of the main reasons for including these types of competences is the demand by employers for graduates with competence-based training that includes social methodological skills, that is, graduates who possess skills that enable them to act effectively in real-life social and professional situations (Rychen and Salganik 2001, 2003).

Generic competences include skills and cognitive abilities that can be classified as instrumental, interpersonal, and systemic.

Instrumental competences include:

- Cognitive skills or abilities needed to understand and use ideas and thoughts related to the issues addressed
- Methodological capacities to interact in a professional environment: time management and learning strategies, decision-making and problem-solving, and the effective use of space
- Technological skills related to the use of technical facilities, computers, and information management skills
- Linguistic skills in both oral and written communication such as appropriate use of synonyms and adjectives and capacity for verbalization and argumentation

Interpersonal competences include skills related to the ability to express feelings or perceptions of an issue, the ability to critique and receive criticism constructively as well as social and interpersonal skills that allow teamwork, and the expression of ethical or social commitments in a socially appropriate manner.

Systemic competences are related to the skills and abilities that allow us to appreciate the relationships and linkages of the parts to a whole. These capabilities include the skills to plan changes to improve systems as well as design new ones and require as a basis the prior acquisition of instrumental and interpersonal skills.

These skills are difficult to evaluate; therefore, for each competence, it is necessary to develop (1) a concrete definition that delimits the meaning you want to express, (2) the relationship to other competences, and (3) the definitions of *sub-competences*, elements, or attributes that make up a competence. These *sub-competences* cannot be developed at the same rate or level. Therefore, each of these elements needs to be defined according to the specific objectives for each of the three acquisition levels corresponding to the first three levels of Bloom's Taxonomy (knowledge, comprehension, and application) that the IEEE and ACM associations consider necessary for undergraduate studies.

Bloom's Taxonomy (Bloom 1956) and later review (Krathwohl and Bloom 1964; Bloom et al. 1984) have been adapted to the world of information technology and communications (Scott 2003; Johnson and Fuller 2006). Recently, Marzano and Kendall (2007, 2008) proposed a new taxonomy of learning objectives which presented a new classification that consists of six levels of processing and three domains of knowledge (see Fig. 9.1). On the one hand, the levels of processing refer to three systems: (1) the self, which refers to the motivation to learn; (2) the metacognitive, which explains the process of setting learning goals and strategies to achieve them; and (3) the cognitive processes including upward information retrieval, comprehension, analysis, and utilization of knowledge. On the other hand, the three domains of knowledge are called (1) information, a body of data that contributes to a specific or synthesized description; (2) mental process, which corresponds to how information is handled to perform actions of various kinds; and (3) psychomotor procedures, which are related to the coordination of body movements for different purposes. Four processing levels are defined for a knowledge system: (1) recovery, (2) understanding, (3) analysis, and (4) utilization of knowledge. This taxonomy has been used extensively in designing learning environments, learning processes, and evaluation systems (Kendall et al. 2008; Hernandez and Rangel 2010).

Either of these taxonomies can serve for defining the learning objectives of the activities designed to promote both technical and generic competencies. Course subjects must be defined according to their formative objectives that, in order to be met, require the student to acquire the competences needed to successfully finish the course. Each level of competence requires the successful achievement of the previous one.

9.3 Web 2.0

Web 2.0 has revolutionized communications worldwide; it is the natural evolution of the Web toward a more communicative, participatory, and social media (Murugesan 2007). As a result of this so-called *collective intelligence* (O'Reilly 2007), users generate massive quantities of data in real time that must be managed and organized

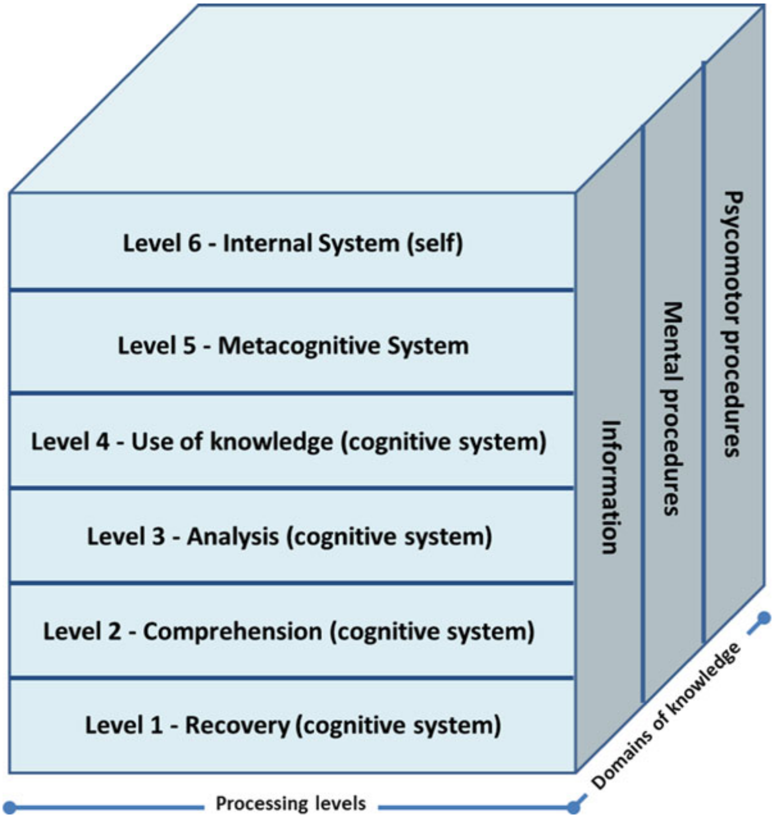

Fig. 9.1 Marzano's taxonomy of educational objectives

properly so that the Web can continue to grow and evolve (O'Reilly and Battelle 2009). Today the Web is a participatory world of changing information in which anyone can find a tool or utility service to meet their communication needs.

One of the most important facets of this revolution is the social aspect, reflected especially in social networks. This social aspect is a reflection of the desire to communicate and the need to create different communities (Birdsall 2007). In this regard, social networking has been a breakthrough that has enabled a generation trained in the use of ICT to lead a revolution in communications. However, although social networks are at the forefront of this process, there are also other types of virtual communities tailored to the needs of users to meet specific functions such as file sharing, content management, learning environments, or information classification. In this sense, "social software" provides the tools necessary for such communities to function, as seen in Table 9.2 (McLoughlin and Lee 2007).

Focusing on education, the framework of Web 2.0 (Ornellas et al. 2009) has favored the emergence of new open virtual learning environments for higher education. The use of open, collaborative, and social objects, such as blogs, wikis, social

Table 9.1 Generic competences

Category		Competence
Instrumental	Cognitive	Thinking: analytical, systematic, reflective, logical, critical, creative, practical, deliberative, and collegial
	Methodological	Organizing time
		Problem-solving
		Decision-making
		Planning
		Continuous learning
	Technological	Database
		Computer as a tool for work
	Linguistic	Verbal communication
		Written communication
		Competence in a foreign language
Interpersonal	Individual	Self-motivated
		Persistence and ability to adapt
		Ethical behavior
	Social	Diversity and multiculturalism
		Teamwork
		Interpersonal communication
		Conflict resolution
		Negotiation
Systematic	Entrepreneurial capacity	Creativity
		Entrepreneurial capacity
		Capacity to innovate
	Organization	Objective management
		Project management
		Quality development
	Leadership	Influence and delegate power
	Achievement	Achievement orientated

bookmarks, podcasts, video channels, and virtual environments like Second Life, is promoting new forms of knowledge construction and representation based on social tools, making learner-centered education a potential reality. These tools enable and encourage informal conversation, dialogue, collaborative content generation, and sharing of information, giving learners access to a vast array of ideas and knowledge that enables the development of cross-curricular competences.

Therefore, Web 2.0 tools can be a valuable aid in integrating cross-curricular competences in university curricula. By basing our assumptions on social and collaborative learning methodologies [Student Teams-Achievement Divisions (STAD), Teams-Games-Tournaments (TGT), Jigsaw II, Team Accelerated Instruction (TAI), …] (Zhao and Knaji 2001) and interactive tools, such as the open source Virtual Learning Environment (VLE) Moodle, social networks, and Second Life, it is our aim to present a set of teaching strategies, tasks, and practices intended to develop such cross-curricular competences for both successful study and future vocational integration.

Table 9.2 Types of social software (McLoughlin and Lee 2007)

Social software category	Examples
Multiplayer online gaming	Multi-user dungeons (MUDs); massively multiplayer online games (MMOGs) such as Second Life, Active Worlds, World of Warcraft, Everquest
Discourse facilitation systems	Synchronous: instant messaging (IM, e.g., Windows Live Messenger, AOL Instant Messenger, Yahoo Instant Messenger, Google Chat, ICQ, Skype), chat Asynchronous: e-mail, bulletin boards, discussion boards, moderated commenting systems (e.g., K5, Slashdot, Plastic)
Content management systems	Blogs, wikis, document management systems (e.g., Plone), web annotation systems
Product development systems	Sourceforge, Savane, LibreSource
Peer-to-peer file sharing systems	BitTorrent, Gnutella, Napster, Limewire, Kazaa, Morpheus, eMule, iMesh
Selling/purchasing management	eBay
Learning management systems	Blackboard/WebCT, ANGEL, Moodle, .LRN, Sakai, ATutor, Claroline, Dokeos
Relationship management systems	MySpace, Friendster, Facebook, Faceparty, Orkut, eHarmony, Bebo
Syndication systems	List-servs, RSS aggregators
Distributed classification systems (“folksonomies”)	Social bookmarking: del.icio.us, Digg, Furl Social cataloguing (books): LibraryThing, neighborrow, Shelfari (music): RateYourMusic.com, Discogs (movies/DVDs): Flixster, DVDSpot, DVD (scholarly citations): BibSonomy, Bibster, refbase, CiteULike, Connotea Other: Flickr

9.4 Developing Cross-Curricular Competences Through Web 2.0 Online Social Objects: A Case Study

The aim of our work is twofold: (1) the identification of some of the most important generic skills in the area of engineering, more specifically in computer engineering, and (2) the formulation of a training framework to integrate them into the classroom through Web 2.0.

Table 9.3 lists the transversal competences ascribed to the degree.

Selected above, the competences analyzed and developed in our study are some of the most relevant for the formation of future engineers—critical thinking, teamwork, and innovation and entrepreneurship:

- Critical thinking: although engineering students are taught in many of their classes to find solutions by following standard procedures, the challenge lies not only on following a set of step processes but on the difficulty to integrate ideas and find a straightforward problem-solving formulation independently.

Table 9.3 Transversal competences in the computer science degree

Transversal competences
CT1. Plan and organize individual work
CT2. Effective oral and written communication (expression and comprehension), knowledge, procedures, results, and ideas related to ICT, with special emphasis on the drafting of technical documentation
CT3. Able to communicate effectively in English
CT4. Make decisions based on objective criteria (experimental data, scientific or simulation)
CT5. Demonstrate initiative and be decisive, providing effective solutions to problems even in situations lacking information and/or time constraints and/or resources
CT6. Show appropriate interpersonal skills
CT7. Find, analyze, criticize, relate, organize, and synthesize information from different sources and integrate ideas and knowledge
CT8. Able to adapt to new situations as well as organizational and technological changes
CT9. Being able to lead, influence, and motivate others, effectively using available resources
CT10. Take initiative to contribute to and/or evaluate alternative solutions to problems, demonstrating flexibility and professionalism when considering different evaluation criteria
CT11. Motivation to continuously improve quality, acting with rigor, responsibility and professional ethics
CT12. Being able to argue and justify decisions logically, knowing how to accept other points of view
CT13. Being able to integrate quickly and work efficiently in single-discipline and multidisciplinary teams in the field of applications, services, and systems, assuming different roles and responsibilities with the utmost respect for fundamental rights and equality between men and women

- Teamwork: defined as the process of working collaboratively with a group of people in order to achieve goals, teamwork implies that team members try to collaborate using their individual skills and providing constructive feedback despite any personal conflict between individuals (Dillenbourg et al. 1995).
- Innovation and entrepreneurship deals with "what, when, and why"; with policies and decisions; opportunities and risks, structures and strategies; staffing, compensation, and rewards. Within this competence, leadership incorporates a number of critical capabilities including the ability to assess risk and take initiative and to make decisions in the face of constraints or obstacles in a team setting. Studies have shown that leaders learn from experience (Kotter 1996, 2001) that they do so in often accidental ways that have required reflection that ultimately led to decision-making within a particular social context and that overcoming challenges and difficulties at work often triggers their self-generative learning capacities.

The material, activities, strategies, and resources used in the research include the following:

- Course outline, tasks, and communication activities made available in Moodle, several Moodle modules used to prepare the presentations and debating sessions
- Use of collaborative Web 2.0 tools (wikis, blogging, glossaries, chat, Skype)

- Course meetings and presentations held in Second Life (SL) virtual environment

The course provides students with a social virtual learning space that allows for synchronous or asynchronous learning and self-paced learning activities that create a managed social space to facilitate teaching and learning (Edwards et al. 2010).

In this course, the socio-constructivist approach (Jackson et al. 2006) is reflected through "activity-based" pedagogies such as project-based or case-based learning (Santally and Senteni 2004). Constructivism is related to, and integrated within, cognitive psychology. Our proposal places the learner at the center of a process based on discovery and collaboration in which tasks that lead learners toward a socially constructed understanding of the learning objectives are developed through a collaborative process. The results are shared with, rather than evaluated by, the instructor—or facilitator—so they can be compared with a more broadly socially accepted interpretations. We use the term collaborative in the constructivist sense. It is this aspect of Web 2.0 tools we seek to explore as many of the skills required to successfully employ these tools within a constructivist learning framework are precisely those measured by cross-curricular competences. The interest that has been expressed for rich activity-based pedagogical scenarios supports the objective of creating more in-depth, integrated, and applicable knowledge in different contexts (Schneider et al. 2003). Such pedagogies are crucial to prepare our students to face the challenges of the modern world where they will be required to be better problem-solvers as well as effective team workers.

As already stated, another important competence developed in the course is communication in a foreign language. One-on-one communication, as well as working groups, is developed through activities such as online debates in the virtual environment of Second Life.

By combining teamwork, decision-making, and communication skills through managing a project or event, students will learn about organization, time management, and problem-solving.

In addition, as foreign language acquisition is becoming an increasingly important aspect of lifelong education, the above-mentioned competences are integrated into the curricula using English as a communicative vehicle. The most effective way to learn a language is to participate in a community in which the target language is used to communicate in a real context. In such an environment, language learners are encouraged to think, speak, and write in the target language. According to Canale and Swain (1980) (Canale 1981), communicative competence consists of four components: grammatical competence, discourse competence, sociolinguistic competence, and strategic competence. Strategic competence is the ability to employ communication strategies using both verbal and nonverbal approaches to maintain communication and plays a crucial role in advancing interlanguage development and achieving communicative competence. Therefore, communicative experience takes places in virtual environments, and the communicative utterances are largely based on the appropriate application of a strategic competence.

Table 9.4 Critical thinking habits

Ability to argue and justify decisions logically, knowing how to accept the points of view of others
Ability to defend their own positions with solid arguments
Ability to distinguish the strengths and weaknesses of any argument
Ability to verify information before offering an opinion
Ability to generate opinions from the information at hand
Ability to draw reasoned conclusions from reading or presentation
Ability to relate facts and concepts
Ability to reflect critically on information received
Ability to present and communicate to others all kinds of arguments
Ability to demonstrate openness and dialogue
Ability to express with precision, rigor, and clarity orally and in writing
Ability to be coherent and orderly in oral and written expression
Ability to clearly demonstrate self-respect and respect for colleagues
Ability to tolerate ideas, thoughts, and views contrary to their own

9.4.1 Critical Thinking Habits

As Table 9.4 demonstrates, critical thinking habits go beyond the simple definition of a single competence but combine several important cognitive abilities, which are essential for developing reasoning abilities that facilitate professional development. Because engineering is a degree based extensively on practical tasks, students must first learn how to manage specific knowledge by appreciating and critiquing different perspectives through independent reasoning and analysis, in order to find the most appropriate interpretation.

Due to the importance of such cross-curricular competences, we have developed a series of activities/tasks which envisage the development of critical thinking skills in order to deepen learners' understanding of the objectives and tasks essential to the discipline of engineering.

Table 9.5 outlines our framework. Several attributes considered essential for the development of this competence are stipulated, as well as several Web 2.0-based activities/tasks. The identification of strategies and knowledge and comprehension levels reflects the previously stated attributes, and the application level/results embody the objectives set at the beginning of each activity.

The first two attributes (ability to think critically and logically and the ability to abstract—creating models reflecting real situations) are developed through the presentation of an engineering problem and several ways of solving it. Several tools can be used to present the problem: a video (or set of videos) uploaded to Moodle, several web pages that deal with the problem, specialized blogs, and engineering forums and discussion panels. Students will be asked to analyze different ways to solve the problem and come up with the best solution. The strategies used include (a) looking for information and (b) analyzing, criticizing, summarizing, and evaluating information. These strategies will determine the knowledge level students

Table 9.5 Critical thinking habits activity proposal

Attributes	Web 2.0 resources and tools	Strategies	Knowledge level	Comprehension level	Application level/results
Ability to critical and logical thinking Abstraction ability (creating models reflecting real situations)	Moodle, Moodle chat, e-mail, and forum, Websites, Blogs, Sloodle (access to SL from Moodle), Skype	Looking for information and analyzing, criticizing, summarizing, and evaluating information	Students must be able to identify and analyze a problem	Students must compare the problem to real situations and analyze them	Students should apply the knowledge acquired in real contexts and situations to solve it
Problem-solving	Websites, Moodle, Moodle wiki, Moodle chat and forum, Sloodle and SL	Look for, relate, and structure information from various sources and integrate ideas and knowledge Leadership	Students must analyze a problem or specific situation	Students must compare the problem with others faced in the same and other contexts	Students should acquire strategies to overcome the problem in real situations and contexts
Capacity of analysis, synthesis, and evaluation	Websites, YouTube, Moodle, Moodle blog, Moodle chat and forum, Videoconferencing	Ability to look for, relate and structure information from various sources and integrate ideas and knowledge	Analyzing, processing, and assessing information related to the previous problem	Comparing the information with different situations	Applying the final information to practical situations and contexts

should achieve by identifying and analyzing a problem to reach the best solution. Beyond that, they will be asked to compare the problem with real situations, with the aim of applying the solution to problems in real contexts.

The third attribute (*problem-solving*) stems from the previous two. After finding a solution to the problem, students are required to share it with their colleagues and with the teacher/tutor both through the Moodle platform and its communication tools (wiki, chat, and forum) and Second Life (SL), where students can meet virtually and discuss ideas and solutions. Problem-solving activities are based on constructivist and interactional tasks with the goal of preparing students for future professional demands, where they will need to work collaboratively in a team.

Finally, the last attribute (*capacity of analysis, synthesis, and evaluation*) is demonstrated when students present their findings and solutions to the original problem.

Individually or in a group, critical thinking and decision-making are pivotal leadership skills; therefore, students are trained in different decision-making techniques, such as authoritative, democratic, and consensus, and practice brainstorming, comparing pros and cons, imagining alternatives, and predicting results.

Research on problem-solving strategies has shown that expert problem-solvers spend more time and effort on understanding the problem (or problem definition) than students or novices do, and this enables them to arrive at better solutions quickly.

9.4.2 Teamwork

The importance of team work was introduced in the first set of activities and will be developed further now. It is an essential competence, and students lacking the ability to work in teams will have difficulty reaching their goals in a constantly changing society that increasingly values professional competence and expertise. By analyzing Table 9.6, we can infer that teamwork is a compound of several important competences, namely the ones based on respect, solidarity, and empathy, but also responsibility and continuous professional development.

In order to lead a group, an understanding of group dynamics is needed; that is why most of the team-building activities in the course are task-based and give students a common goal, limitations, and a time frame. Table 9.7 is a summary of the activities carried out to develop this competence. As with critical thinking, two interrelated attributes are developed simultaneously through a Webquest: (a) the ability to work efficiently in single-discipline teams and to collaborate in a multidisciplinary environment and (b) interpersonal relationships.

Students will be invited to form teams. Several resources will be used to convey the objectives as well as the instructions, namely Moodle and its communication tools (chat, forum), as well as videoconferencing using Skype. In order to compare information and organize the tasks and procedures they must follow, students will share their findings through two Moodle resources, a wiki and a blog. As teamwork

Table 9.6 Teamwork

Being able to integrate quickly and work efficiently in single-discipline and multidisciplinary teams in the fields of applications, services, and systems, assuming different roles and responsibilities with the utmost respect for fundamental rights and equality between men and women
Ability to integrate with ease
Ability to empathize with others
Ability to respect the ideas and behavior of others
Ability to listen to others
Ability to tolerate diversity
Ability to work well with others
Ability to commit to the objectives of the job and/or projects
Ability to be flexible in sharing tasks and adapting to schedule changes
Ability to propose ideas to improve performance without ignoring the ideas of others
Ability to deliver tasks on time
Ability to offer support to the group
Ability to motivate team members
Ability to assume responsibility for mistakes
Ability to research other disciplines and find connections between them
Ability to approach problems from different perspectives
Ability to assess the work, ideas, and knowledge of others
Ability and willingness to learn new skills
Ability to propose working alternatives
Ability to try to understand and relate text or data from various sources

Table 9.7 Team work activity

Attributes	Web 2.0 resources and tools	Strategies	Knowledge level	Comprehension level	Application level/results
Ability to work efficiently in unidisciplinary teams and to collaborate in a multidisciplinary environment	Moodle Moodle chat, forum Moodle blog Moodle wiki Videoconferencing Skype Sloodle and SL	Looking for and finding information on a given problem or situation to be shared with other peers	Knowing ways of solving problems and sharing them with others, in order to find a solution	Comparing one's information with the one gathered by peers	Students should work in teams to analyze the information each one gathered and present a final solution (or solutions) to the problem initially given
Interpersonal relationship ability	Moodle Sloodle and SL Moodle wiki Videoconferencing Skype Moodle blog	Interacting with tutor and peers in order to achieve the goals set at the beginning of the course	Knowing and interacting with colleagues and find a way of working out the problems set by the tutor	Understanding people's differences and comparing them to one's own	Students should respect personal differences and work together in pursuing the course objectives

Table 9.8 Innovation and entrepreneurship (leadership)

Being able to effectively lead, influence, and motivate others using available resources
Ability to be viewed as a leader by colleagues
Ability to promote learning, collaboration, and trust among team members
Ability to ensure compliance with the goals established in their work group
Ability to be a role model for others
Ability to identify strengths and weaknesses of teammates and distribute responsibilities accordingly without undermining anyone

emphasizes collaborative work, assignments include an individual phase followed by a collaborative one, each with specific tasks and deadlines. Students are encouraged to use the synchronous as well as asynchronous online communication and collaborative tools. This student-centered approach requires students to work together by discussing, presenting and defending ideas, exchanging points of view, and critically and actively engaging in the learning process. Thus, through collaborative problem-solving and mutual support, students find the solution to the quest. As soon as they have gathered all the information needed to solve the quest, they will be asked to share and compare information in order to prepare the final presentation. Teamwork is an integral part of the task and essential in order to solve the problem and complete the task. Through this, students develop the ability to work together as well as respect for differences and each other.

9.4.3 Innovation and Entrepreneurship

According to Tinelli (2000), leadership competences result from the development of personal perspective (identity) and the capacity to deal with change (learning outlook). This competence will embody the final objective of all the tasks developed.

As presented in Table 9.8, leadership implies the capacity of not only leading others but also developing innovative solutions by working together, dividing responsibility, delegating tasks, and relying on each other during the knowledge acquisition process.

Therefore, we have stipulated three attributes necessary to develop this competence: (1) ability to work autonomously, (2) initiative, and (3) being able to develop innovative ideas and solutions (Table 9.9).

Bearing in mind the Webquest from the previous activity, the first attribute involves gathering information from different sources as well as the analysis and integration of ideas and knowledge. The resources used are available through Moodle on websites and can be shared and discussed through Google documents. Therefore, the knowledge and comprehension needed and the solution they must reach must be achieved through analyzing information, finding the best solution, and solving difficulties and problems throughout the process in order to complete the Webquest tasks.

Table 9.9 Innovation and entrepreneurship (leadership) activity proposal

Attributes	Web 2.0 resources and tools	Strategies	Knowledge level	Comprehension level	Application level/results
Ability to work autonomously	Moodle Moodle chat and forum Sloodle and SL	Ability to look for, relate, and structure information from various sources and integrate ideas and knowledge	Finding information and solutions to situations	Comparing a given situation to others in real contexts	Students must find information and apply it to a given problem and situation
	Websites Google documents (cloud computing)		Finding the most useful way of accomplishing difficulties and overcoming problems	Experimenting different solutions to a given problem	Students should experiment different solutions to a given problem or situation
Initiative	Moodle Moodle chat and forum Sloodle and SL Websites	Ability to analyze, criticize, summarize, evaluate information, and problem-solving Leadership	Having initiative to overcome problems and difficulties as well as to find solutions to different situations and problems	Being able to compare situations and the best ways of overcoming them	Presenting solutions to real problems and situations
Being able to give innovative ideas and solutions	Moodle	Being able to select information and adapt it to the pursuing of the desired results	Analyzing information and different ways of solving situations and problems	Comparing different situations and possible solutions	Giving innovative ideas and solutions to situations and problems
	Moodle chat and forum Sloodle and SL Websites	Ability to find innovative solutions			

The second attribute (initiative) derives from the need for leadership to organize information, delegate tasks, and ensure their completion, which requires initiative in order to overcome problems and find solutions. This is developed through the preparation for the final presentation of the Webquest outcomes in Second Life. The leader must organize the team, delegate tasks and responsibilities, and motivate his/her colleagues to complete the task.

Finally, the third attribute (being able to provide innovative ideas and solutions) reinforces all of the above: finding an outcome is not enough—it must be original and innovative, because only that way will the main goal be achieved successfully. The evidence for this competence is the quality of the final presentation in SL—completing the Webquest.

9.5 Final Considerations

Increasingly research demonstrates the effectiveness of constructivist and collaborative learning in VLEs environments which support knowledge acquisition, self-direction, immersion, interactivity, comprehension, and evaluation. Thanks to the integration of Web 2.0 tools, the potential exists to take advantage of these tools to work on cross-curricular competences.

Throughout the delivery of course, students are encouraged to work critically, collaboratively, in teams and autonomously—important skills that can be transferred and applied to other areas within their field of study as well as in their professional careers. As compared to traditional approaches, e-learning technologies have the potential to foster innovative pedagogies and to promote collaboration, knowledge construction, and personal development of the student.

Apart from cross-curricular competences, the framework facilitates English language acquisition through its integration into virtual learning environments, Web 2.0 tools, and management platforms. Through experiencing the virtual world of Second Life, students can construct meaningful contexts in which to improve their communicative competence. In short, the development of the project will allow students to develop some of the key competences such as collaboration, negotiation, communication, problem-solving, and the management and sharing of information.

There are currently two approaches to the incorporation of generic skills training in Spanish universities in accordance with the new European Higher Education Area curricula. One approach aims to develop these skills through specific subject or subjects within a degree that focus on cross-curricular competences. For example, the computer engineering degree at the University Carlos III of Madrid includes subjects such as "search techniques and use of information," "techniques of oral and written expression," and "humanities" in its curriculum. Other universities advocate generic skills training within subjects relating to technical expertise. Both approaches have advantages and disadvantages.

In the first case, the teacher focuses specifically on the formation of generic skills within the professional context of the field covered by the degree, and these form the basis of the evaluation criteria. In the second case, as the subject is focused primarily on technical expertise, the risk is that the teachers do not adequately focus on the generic skills that ought to be covered. It should also be noted here that teachers may not have the experience necessary to foster these skills and therefore need training prior to their delivery. In either case, the extent of acquisition of each competence needs to be evaluated. Although this is not an easy task, the incorporation of Web 2.0 tools in the teaching of cross-curricular competences provides a solid basis from which to begin.

In either case, the most important point is that the successful evaluation of cross-curricular competences takes place. However, given that cross-curricular competences are dealt with in one form or another in all subjects, if their evaluation occurs only in one or two subjects within a degree, a significant opportunity to record learning would be missed. Therefore, it is always necessary to evaluate cross-curricular competences in each subject, and this requires teacher training. But above all, coordination and monitoring of each subject is needed in order for teachers and students to monitor achievement in each of the competences. Alternatively, a committee or workgroup of teachers could monitor each student's progress, and the assessment would be carried out jointly within the committee rather than by each teacher individually within each subject.

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Chapter 10
Proposal of a Model and Software for Identification of Social Presence Indicators in Virtual Learning Environments

Hélvia Pereira Pinto Bastos, Júlia Kikuye Kambara da Silva, Magda Bercht, and Leandro Krug Wives

10.1 Introduction

This chapter presents part of the research developed for the doctoral program in Information Technology and Education at the Universidade Federal do Rio Grande do Sul (PGIE-UFRGS), a case study with the objective of identifying *social presence* (SP) (Insko 2003; Gunawardena and Zittle 1997; Garrison et al. 2001) in virtual learning environments (VLEs), aimed at aiding tutors in distance education courses. This research comprises two stages: (1) construction of a model for mapping and labeling verbal indicators of SP in students' messages posted in a Moodle environment and (2) development of a computational tool to process these indicators and provide the student's level of SP. The corpus of study is made up of forums and chats in a postgraduation course for public teachers.

As writing is still the main channel of communication in online education, it is relevant to identify and understand how individuals express their affective states, their conversational strategies, as well as the lexicon and syntactic structures they use to enhance their feelings and communicative purposes. In distance education, interactions are considered as a critical factor in course retention because they promote perception of belonging in the group, and mitigation of isolation feelings, usual in this learning modality. Point out the relevance of research on SP due to the increasing use of interactive media in education. However, it is difficult for researchers to aggregate results as the existing measuring instruments were not created for CMC events, demanding, for that reason, the elaboration of other survey tools, such

H.P.P. Bastos (✉)
Instituto Federal Fluminense, Campos dos Goytacazes, RJ, Brazil
e-mail: helviabastos@yahoo.com.br

J.K.K. da Silva • M. Bercht • L.K. Wives
Universidade Federal do Rio Grande do Sul, Porto Alegre, RS, Brazil
e-mail: jkksilva@inf.ufrgs.br; bercht@inf.ufrgs.br; wives@inf.ufrgs.br

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as specific questionnaires (Mykota and Duncan 2007). Therefore, our work is a contribution to studies focused on understanding and measuring student verbal behavior in distance education.

SP and belonging are similar concepts, both relevant in the observation of how learners project themselves in interactions via computer-mediated communication (CMC), as they can provide clues of greater or lesser motivation and satisfaction in online learning (Palloff and Pratt 2002; Mackey and Freyberg 2010). According to Wheeler (2005), SP is essential in any pedagogical situation, but mostly in online programs. Garrison et al. (2001) explain that SP is a factor that contributes to make online interactions more pleasant and satisfactory, thus collaborating to more successful experiences.

Conceptualization of SP and its contribution to the understanding of how individuals express and reveal themselves in forums and chats are discussed in Sect. 10.2. The model used in the identification of SP textual cues is described in Sect. 10.3. This is followed by the presentation of the software developed to process SP indicators and the analysis of results from experiments made with such computational tool.

10.2 Social Presence in Text-Based Online Interactions

The review of literature shows that the concept of SP in VLEs has different definitions. According to Insko (2003), two meanings are more frequent: the sensation of "being there" (even if physically absent) and the "illusion of non-mediation" (in which the person seems to be unaware of the communication medium). For a better understanding of the issue, we resume definitions by (1) Gunawardena and Zittle (1997), in which SP is the degree to which individuals are perceived as "real" in mediated communication, and (2) Garrison et al. (2001), for whom SP is the ability of people to project themselves both socially and emotionally, that is, to feel "present" in nonphysical environments. This sensation of "being there" can be fostered by interactive tools, such as e-mail, discussion forums, and chats, and enhanced by the use of paralinguistic elements (graphic resources).

These definitions make clear that the way participants interact with one another can be a more meaningful indication of motivation and interest than the student's register of attendance (Tu and McIsaac 2002). Online interactions can also help learners to adapt to studying and learning in VLEs because such interactions may increase or limit their presence and involvement in these environments.

Drawing particular attention to the relevance of the linguistic aspects of CMC, especially in forums and chats (a rich corpus of SP cues), this study considers "social presence" as *the verbal manifestation of affect and interaction made by individuals in relation to the group and to the virtual learning environment*. Complying with this definition, our template comprises four main categories—affect, interaction, social cohesion, and force—as interdependent and determinant factors in the development of relationships and in the way individuals create images about one another in computer conferencing.

The absence of cues found in face-to-face conversation (body gestures, facial expressions, rhythm and tone of voice, among others) is overcome by the linguistic content of the messages which, in turn, help individuals establish what Walther (1996) calls "hyperpersonal relations," that is, with a high degree of social presence. Agreeing with Walther, Gunawardena (1995) and Wheeler (2005) think CMC resources do not present less social cues; on the contrary, they can be a stimulating way to promote sense of community and collaborative learning. As explains, "By making the language form and content performative and playful, participants in CMC enhance the appeal of the discourse, build online identities and foster fun relationships." Therefore, considering that language is a social practice that organizes and structures human relations (Bakhtin 2000; Vygotsky 1998), interactions in VLEs play a significant role in establishing more meaningful and productive relations among participants (Su et al. 2005; Martinez 2003; Palloff and Pratt 2002; Garrison et al. 2000).

10.3 Language and Context in Forums and Chats

Due to the physical distance typical of online education, written communication is a significant resource to develop and keep affect among participants. This occurs because the student's log register is not enough to attest his/her involvement and motivation in the course. Therefore, we reaffirm the relevance of observing discursive interactions in order to understand how learners feel about their peers and about the learning environment per se, that is, how he/she discloses social presence.

In this study, the theoretical foundations for text analysis are found in Bakhtin (2000) and in the pragmatic approach of language. According to Koch (1997), pragmatic linguistics is concerned with productions made in concrete situations, under certain conditions of production. Text analysis made in this perspective should take into account the speaker's linguistic choices and their effects upon the audience. This is also related to Bakhtin's notion of *polyphony*, that is, the idea that what we say is always a response to what has been said before, or as anticipation of what will be said. Bakhtin's dialogic view of language is linked to Vygotsky's concept of the collective construction of meanings (1998), since, as Akhutina (2003, p. 101) puts it, both authors "start with ideas about the social nature of the human psyche and how it is mediated by signs."

The heterogeneous nature of discourse with its multiple meanings and formats is also found in Bakhtin's study of speech genres (2000). Classified as *netspeak* by Crystal (2001), and as *emerging genres* by Marcuschi (2004), forums and chats are considered to be hybrid genres. This is because they have elements of traditional textual genres, as well as those produced by digital media. This mixture results in texts with marks of oral speech, used to overcome the speaker's physical absence, and elaborated in accordance with the pace of communication in contemporary society (for instance, short and incomplete sentences, abbreviations, phonetic modifications, spelling violations, icons, Web links).

Koch (2009) says every text results from the mobilization of the following elements which operate together within a certain context: *the producer/speaker, the text, and the reader/listener*. Thus, text analysis cannot be limited to the study of isolated sentences; on the other hand, it must consider stances in the production situation (who speaks, with whom, when, in what situation, and what for).

With this in mind, context must not be disregarded in the process of mapping students' posts, since it is in the thread of comments that meaning emerges. Halliday (1978) presents two types of context: (1) *context of culture*, which relates to aspects external to the text, and (2) *context of situation*, which provides clues of how the text is produced, in other words, the lexical–grammatical choices made by the speaker in order to accomplish his communicative purposes. Therefore, the context of culture (digital media, in this case) determines how the genres forums and chats are shaped and produced. The context of situation is related to the specific discursive instances that provide SP cues for this study. For instance, in a forum which discusses technology in education, participants are likely to use less affect cues than in a chat for clarifying issues related to the course program or usability.

The next section presents the *Presence Plus* model (PPlus), designed to identify and classify SP cues in students' posts.

10.4 Template for Identifying Textual Cues of PS

Forums and chats in VLEs are tools that not only strengthen the "being together" but also make up a rich context for identifying social presence in online courses.

According to Bednarek (2008, pp. 9–10), there are several approaches in the study of linguistic corpora. Our model is based on these two: (1) the "pragmatic-text linguistic approach" which focuses on different aspects, among them, syntax, communication strategies, verbal phenomena, emotive prosody, and speech acts, and (2) the "systemic-functional approach" based on Halliday's systemic-functional linguistics (1978), which emphasizes appraisal and the interpersonal function of language.

Construction of the PPlus model was based on various approaches in linguistics (discourse analysis, speech act theory, conversation analysis, language functions, and systemic-functional linguistics). Corpus analysis also considered differences in written and spoken language, as well as the different divisions in language studies (morphology, stylistics, syntax, pragmatics, prosody, and semantics).

Along with this theoretical linguistic support, the study used content analysis to do the mapping and categorization of the SP indicators (units of analysis) that would be included in the PPlus model. According to the term "unit of analysis" refers to the basic text unit to be classified, ranging from one or more words to graphic elements.

To identify SP textual cues, we propose units of analysis adapted from the template given by Rourke et al. (2001). To this, we have added subcategories and a fourth category—force—found in the appraisal system of Martin and White (2005) and reviewed in Vian Jr.'s study of this model for Portuguese (2009). We have

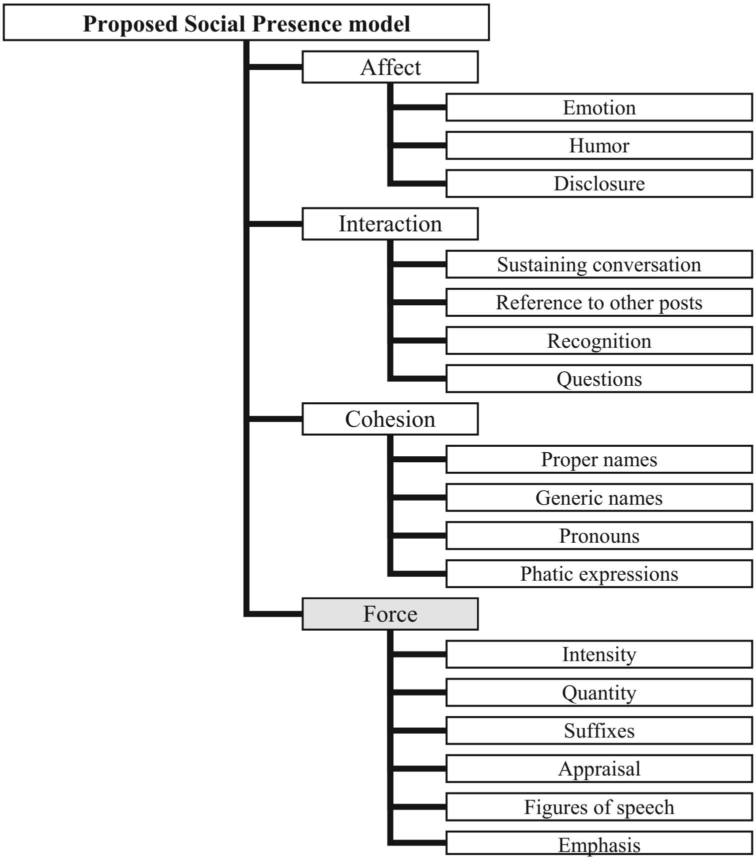

Fig. 10.1 The proposed PPlus and its corresponding categories

named this new set of classes *Presence Plus* (PPlus), as it is an actual expansion of the original frameworks.

The model has four categories—affect, interaction, cohesion, and force—subdivided in several units as shown in Fig. 10.1 and detailed in Sect. 10.4.1. Affect and interaction are close concepts, notably in social interactionist theories such as those of Vygotsky (1998). However, this terminology is used here in its usual, everyday meaning of expression of affection and communication among individuals.

Each subcategory is divided in labeled units, which provide a reference code for the software programming. For measuring purposes, all units are equally rated. During the content analysis and stage of mapping the messages, we observed that, quite often, indicators overlapped because they expressed distinct communicative purposes. To comply with these multiple possibilities, some units were marked and counted more than once, that is, classified in different subclasses or indicators. For

Table 10.1 *Presence Plus*: subcategories and indicators of affect (AF)

Subcategory	Indicators	Examples
AF1. Emotion	AF1a. Interjections	Oh, dear; huh
	AF1b. Onomatopoeia	Kkkk
	AF1c. Emoticons and gifs	;) / =P / 
	AF1d. Repetitious punctuation	!!!! / ??? / !?
	AF1e. Repeated letters	Veeery;
	AF1f. Enhancement	Capitalization
		Color
		Bold
		Italics
		Quot. marks
AF2. Humor	AF2a. Sense of humor	What a moron
AF3. Disclosure	AF3a. Vulnerability	Can't do it!!!
	AF3b. Personal life	Had to travel

instance, the phrase *LOVED IT* contains two units—capitalization and the appraisal word *loved*. This was also the case when more than one editing resource was used (color + bold).

The constituting categories and indicators of the PPlus model are detailed in Sect. 10.4.1.

10.4.1 Affect

In our model, the term *affect* is used as a synonym for *affective processes*, a concept used by Scherer (2005) to encompass notions like preferences, attitudes, mood, affective dispositions, and interpersonal stances. As to *emotion* and *humor*, they are used in their common sense to name subcategories of affect, following Rourke et al.'s model (2001). Our template has the subcategories shown in Table 10.1 to express *affect* (AF).

Graphic tools (emoticons, repeated punctuation, editing resources, among others) are important resources available to the speaker in the absence of nonverbal cues used in face-to-face communication. Sense of humor and self-disclosure are also frequent aspects of chats, as this genre allows for more informal conversations, usually aimed at fostering sociability. These instances can promote greater proximity among participants, and opportunity to express mood, to reveal feelings about others or about the topic under discussion.

10.4.2 Interaction

The notion of interaction that oriented our model is that of simple and usual communication among people by means of language in its various forms and purposes.

Table 10.2 *Presence Plus*: subcategories and indicators of interaction (IN)

Subcategory	Indicators	Examples
IN1. Sustaining conversation	IN1a. Use of the reply function	Re:
	IN1b. Discourse markers	Well, (…)
IN2. Reference to other posts	IN2a. Paraphrasing	As Maria said
	IN2b. Quoting	"The Web is…"
	IN2c. Complimenting	Congratulations
	IN2d. Agreeing	I agree
	IN2e. Disagreeing	I disagree
IN3. Recognition	IN3a. Thanking	Thanks for…
	IN3b. Apologizing	Sorry for…
	IN3c. Offering help	I can help you
	IN3d. Motivating	Don't give up!
	IN3e. Sympathizing	We understand your concern
IN4. Questions	IN4a. Clarifications	How do I…?
	IN4b. Requests	Can you send me…?

For *interaction* (IN), we have units referring to strategies that, according to Rourke et al. (2001, p. 7), "build and sustain relationships, express a willingness to maintain and prolong contact, and tacitly indicate interpersonal support, encouragement and acceptance of the initiator." Hence, we have included indicators such as agreeing, complimenting, thanking, offering help, and requests. The "reply" resource is also a clear indicator of interactive responses in CMC (Table 10.2).

10.4.3 Social Cohesion

We use "social cohesion" to establish a distinction from "textual cohesion," term applied in linguistics to classify words and phrases that provide progression and continuity in texts. Rourke et al. (2001) explain that this category includes actions that produce, foster, and sustain group commitment. In our model, the subcategories of *social cohesion* (CO) are detailed in Table 10.3.

A common cohesive resource available in the linguistic system is *referencing* (Halliday and Hasan 1976). References can be made to elements within the text (*endophora*) or to the situation (*exophora*). Such ways of referencing are usually accomplished by using names or personal and demonstrative pronouns. In Portuguese, personal pronouns are often omitted because verb endings can signal subject and tense.

Phatic expressions are discourse strategies commonly found in forums and chats, not only to express ideas or facts but also to confirm that communication is actually taking place (Vetere et al. 2005). As a rule, our corpus shows that these SP indicators are frequently used with vocatives or generic names.

Table 10.3 *Presence Plus*: subcategories and indicators of social cohesion (CO)

Subcategory	Indicators	Examples
CO1. Proper names	CO1a. Vocatives	Hi Maria
	CO1b. Subject or object	I sent it to Prof. Jones
CO2.Generic names	CO2a. Vocatives	Hello, teacher
	CO2b. Subject or object	Students like to…
CO3. Pronouns	IN3a. 1st person	Our discussion…
	IN3b. 2nd person	You can…
	IN3c. 3rd person	People say…
CO4. Phatic expressions	CO4a. Greetings	Hello
	CO4b. Farewells	Bye
	CO4c. Wishes	Have a good wkd

Table 10.4 *Presence Plus*: subcategories and indicators of force (FO)

Subcategory	Indicators	Examples
FO1. Intensity	FO1a. Adverbs and adverbial clauses	I liked it very much
	FO1b. Comparatives	Better, the worst
FO2. Quantity	FO2a. Indefinite pronouns	A lot, none
FO3 Suffixes	FO3a. Augmentatives	"-ão" (= big)…
	FO3b. Diminutives	"-inho" (= small)
FO4. Appraisal	FO4a. Appraisal words	Excellent, awful
FO5. Figures of speech	FO5a. Analogies and metaphors	A dream come true…
FO6. Emphasis	FO6a. Reinforcement	Yes, I do love it.

10.4.4 Force

As explained above, this category was taken from the appraisal system (Martin and White 2005). In their framework, "force" is part of the subsystem "graduation" to express evaluation and intensity. In other words, words and phrases in this category (FO) may reveal the semantic and syntactic value of the lexicon used by speakers, that is, their judgment and affective attitude towards their peers or the pedagogical situation. By using intensifiers, figures of speech, syntactic reinforcement, and other discursive resources shown in Table 10.4, speakers make their presence more explicit in the conversation.

Labov (1984, pp. 43–44) states that *intensity* "operates on a scale centered about the zero, or unmarked expression, with both positive (aggravated or intensified) or negative (mitigated or minimized) poles." Following this idea, our indicators of *force* (FO) present units that express intensity, quantity, appraisal, figures of speech, as well as some specific Portuguese structures that operate as intensifiers (FO3 and FO6).

10.5 Processing Social Presence in Students' Posts

Using the text cues marked in the manual analysis, we developed the software Presente!—a program with a number of tools that collect and analyze logs in forums and chats posted in a Moodle-based course. One of the first problems to overcome was the integration of the program with this VLE. Even though Moodle offers an application programming interface (API), we decided to develop a nonintegrated tool first. This presented two relevant advantages: (1) development of the tools can be entirely directed to the algorithms of analysis, and (2) the tool can be used to process posts originated in any learning environment, as long as the information is stored (i.e., exported or converted) to a specific file format, recognized by the analysis tool.

The analysis process was carried out in three stages: (1) collection/importation of data, (2) definition of text cues, and (3) analysis of the occurrences of the cues. A different tool was developed for each step. A positive feature of this method is that tools are uncoupled, allowing for extending, modifying, or replacing a tool without affecting the others. To do this, we defined entrance and exit patterns for each one. Thus, any tool that follows the pattern can be used.

Since each subject of the course has a different amount of forums and chats, isolated from the others, it is necessary, in the collection/importation stage, that the user who wishes to analyze social presence (e.g., the teacher) enters the Moodle page, selects each forum, and exports it. Exportation is simple; all the user needs to do is to save the forum in HTML (an option found in every Web browser). To make this task automatic and easier to handle, we used a Firefox plug-in (DownThemAll![1]).

After saving the forums as HTML, the files must be analyzed in order to identify each post, its author, title, and content. Once these are identified, data is saved in an XML file in the format presented next, in Fig. 10.2.

In which:

- <topics> is the root tag of the XML tree, with several possible <topic_n>.
- <topic_n> encapsulated in a HTML file referring to a forum, in which n varies from 1 to the number of HTML files; a <topic_n> may have several tags <post_m>.
- <post_m> refers to one post only, with m going from 1 to the number of posts.
- <title> is the title of the post; 301798_1_En is the author of the post; <date> is the date of the post.
- <content> is the content of the message.

This is a standard format and must be followed by any file exporter developed for any VLE. For this study, we developed an exporter using the Ruby language[2] because it has functions for developing syntactic analyzers and regular expressions. Our exporter analyzes the HTML files saved by the user, and converts them into XML, by using the format previously described.

[1] http://addons.mozilla.org/pt-br/firefox/addon/downthemall/.

[2] http://www.ruby-lang.org/.

```
<topics>
  <topic_n>
    <post_m>
      <title> … </title>
      <author> … </author>
      <date> … </date>
      <content> … </content>
    </post_m>
    <post_m+1>
      …
    </post_m+1>
  </topic_n>
  <topic_n+1>
    …
  </topic_n+1>
</topics>
```

Fig. 10.2 Relationship between subject-community-tools/signs

The SP categories are relatively stable, but can change according to the theoretical approach being used. Also, the text cues used to identify each SP category are not fixed, as they can vary according to the context. For this reason, we developed a tool for defining SP categories that allows for management (insertion, removal, alteration) of corresponding text cues. This gives flexibility to the user, who can text different options and refine analysis of posts. The main screen of the tool, developed in Java, shows the different configurations of classes and indicators. These can be saved in different files, be downloaded, and modified according to the desired type of analysis. Multiple versions and views of the social categories can be developed and chosen afterwards depending on the purposes of the analysis. The main screen contains three regions: the area on the left presents the four SP categories, each one with its different levels, according to the depth or granularity of the analysis. For each category, there is a set of related text cues which can be edited in the main region.

As the tool was being developed, we noticed different types or patterns of text cues; thus, for each one, a different recognition algorithm was established. The tool was developed in a method that allows new algorithms to be added without requiring its complete development. Different algorithms can be used to identify text cues. For instance, the "simple expression" algorithm identifies terms (simple or multiword expressions), but with a sequence of characters exactly equal to the one registered in the software. Another algorithm—"bold"—indicates that the sequence must be found only if it is in bold type. Other recognition patterns and algorithms in the software are regular expressions, italics, capitalized words, proper names, etc.

Due to the impossibility of using a parser for optimum syntactic classification, the software Presente! was programmed to perform a lexicometric study[3] of the text cues marked in the manual analysis. To do so, lists of words, phrases, and idiomatic expressions were inserted in the software.

[3]Measurement and analysis of the frequency of words or segments in a text (Cousteaux 2009).

The next section discusses results obtained in both manual and automatic corpus analyses.

10.6 Methodology and Discussion

To validate the PPlus model and verify the effectiveness of the software Presente! in identifying and classifying SP cues in different *corpora,* we have followed several procedures, including corpus analysis in two distinct VLEs and survey questionnaires applied to students and tutors. Content analysis and the resulting model of SP categories were done in a course on computer literacy for 130 public school teachers (corpus CEII,[4] from now on). The corpus of study consisted of 2,049 messages posted by students in forums and chats offered in six course disciplines (*concepts, editors, images, concepts of the Web, concepts on the Web, digital medias, educational software, LVEs, and their application*).

For this discussion, we have selected results from the manual and automatic analyses of SP indicators in two discussion forums (FR-010 and FR-012), as shown below (Table 10.5).

The automatic text processing has identified less textual clues than the manual one (i.e., 17.2%), and it means that the software was able to identify 82.8% of the cues marked in the manual analysis. To us, it indicates that the program reached a satisfactory level of identification of SP cues.

The different results also reflect the current limitations of the program. In its present configuration, the software does not:

1. Identify typing mistakes. The manual analysis marked several occurrences of this type that were not identified by the program.
2. Distinguish acronyms from words typed in capital letters. This means that all acronyms were wrongly classified as AF1f (enhancement).
3. Identify direct quotations (IN2b) from words enhanced by quotation marks (AF1f).
4. Distinguish whether pronouns refer to first, second, or third persons. Without a parser, the program grouped all pronouns as CO3—a fact that does not interfere in the final counting of this subclass.
5. Distinguish the different types of questions (IN4) as “clarifications” or “requests.”

The first three items may be solved by inserting new algorithms into the program. Identification of misspelled words can be done by similarity. Being related to syntax, items 4 and 5 depend on the use of a parser. Another drawback in the current software version is the fact that it operates with preregistered cues only. This demanded the registration of a new set of generic names in a second experiment

[4]CEII: Curso de Especialização em Informática Instrumental. http://www.inf.ufrgs.br/informatica-uab/.

Table 10.5 Comparison of manual and automatic analyses of PS

Forum	Manual analysis	Automatic analysis	Difference between computational and manual analysis (%)
FR-010	4,855	3,401	7.0
FR-012	975	999	10.2
Total	5,830	4,400	17.2

carried in another Moodle-based course (corpus CTST[5]). Instead of *teacher*(s), *student*(s), and *learner*(s), participants in CTST used generic names related to their professional activity (*technician*(s), *manager*(s), *electrician*(s), *employee*(s), for instance).

Besides that, even though the software is not ready to process all SP indicators of the PPlus model, our experiments showed that automatic analysis of forum and chat posts is more viable and convenient than manual analysis, as the latter is quite time consuming and liable to error. On the other hand, there are some linguistic features of subjective nature that are difficult to be identified by computational processing, but easily understood by readers such as figures of speech and humorous comments. The manual study made in the two forums used in the research shows that these features correspond to, respectively, 1.03% and 2.66% of the total amount of PS occurrences—figures that, the authors believe, are not significant in the final counting of SP text cues.

Further development of the program includes its actual insertion in the Moodle platform, so that tutors can fully benefit from the tool, obtaining, for instance, the students' degree of SP in a certain subject or throughout the course. This will also allow for a more clear perception of the greater or lesser relevance of having such diagnosis tool in a VLE. Further study should also involve experiments with various formulae to obtain the learner's degree of SP throughout the course and its usability potential.

As for the PPlus model, the authors have identified the need to submit it to other experts' review as future research. This procedure may provide the evaluators' opinion on the correct classification of the SP indicators and the need to delete or add any indicators to the model.

10.7 Conclusion

The study introduced *Presence Plus*, a model for identifying and labeling indicators of social presence (SP) in text-based communications carried in VLEs. The model is an expansion of the categories found in Rourke et al. (2001) and in Martin and

[5]CTST: Curso Técnico de Segurança do Trabalho. http://ead.iff.edu.br/course/view.php?id=110/.

White (2005), with SP indicators that attend to specific features of the Portuguese language. Categories (affect, interaction, social cohesion, and force) are subdivided in indicators derived from a content analysis of forums and chats in an online post-graduation course for public teachers.

Experiments and development of the software Presente! concentrated on processing and counting all units of analyses in the corpus. This provided quantitative data regarding prevalent subcategories and indicators in the corpus of study. Future work concerning the PPlus model and the software presents a wide range of possibilities, including those mentioned in Sect. 10.4. To be more specific, usability issues regarding the easiness of use and navigation of the software should be evaluated and improved. We should also perform an evaluation of the effectiveness of the system in relation to a pedagogical point of view, considering teachers, which are the actual users of the system.

Development of the PPlus model and software Presente! aims at helping tutors in distance programs to diagnose the students' level of involvement, motivation, and participation in the course. The authors believe this may contribute to alert tutors to the need of making interventions and sustaining learners' interest in the program—actions that might prevent eventual dropouts and increase performance in the course. However, experiments concerning the usability and practicability of having the tool in VLEs remain to be verified.

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Chapter 11
Collaborative Writing with Wikis: Pedagogical and Technological Implications for Successful Implementation in Teacher Education

Said Hadjerrouit

11.1 Introduction

The development of Web 2.0 technologies has brought up a more collaborative way of using technology in education. Among those technologies, wikis have received huge attention in recent years. Wikis are supposed to foster collaborative writing, information sharing, virtual discussion, and group interaction (Hughes and Narayan 2009; Jones 2010; Wheeler et al. 2008). One of the best well-known wiki platforms is MediaWiki (Kasemvilas and Olfman 2009). MediaWiki has collaborative features that enable a document to be edited by multiple students. By writing collaboratively, students generate content for the wiki that is automatically recorded in a data log. This facilitates the analysis of students' contributions to the wiki. MediaWiki has also a discussion page that supports written communication between participants. In line with the recent development of wiki technologies, literature on collaborative learning indicates that learning is more beneficial to the students when they collaborate to perform a task than individual work (Minocha and Roberts 2008; Thompson and Ku 2006; Vygotsky 1978; Witney and Smallbone 2011). Collaborative learning also fosters group interaction, shared understanding, active participation, and engagement with peers. Furthermore, collaborative learning is supposed to facilitate collaborative writing, an activity that involves multiple authors to produce a collective document (Chao and Lo 2009; Wheeler and Wheeler 2009). However, although wikis represent an innovative and potentially powerful tool for collaboration and information sharing, putting students together does not automatically result in collaborative work, without careful consideration of a sound pedagogy and technological issues (Cole 2009; Leung and Chu 2009; Thomas et al. 2009). The main goal of this chapter is to investigate the extent to which wikis

S. Hadjerrouit (✉)
University of Agder, Servicebokѕ 422, Kristiansand 4604, Norway
e-mail: Said.Hadjerrouit@uia.no

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support collaborative writing in teacher education. The work draws on key concepts of collaboration to analyze students' collaborative writing activities performed on the wiki. The work also discusses pedagogical and technological implications resulting from the findings.

11.2 Research Questions

Although perception-based studies are still dominating the literature in wiki research, a growing number of studies have drawn on the data log generated by wikis (Leung and Chu 2009; Judd et al. 2010; Meishar-Tal and Gorsky 2010). Of particular interest for the analysis of the data log is the history function that stores all activities performed by each student in terms of work distribution, level of contribution, types of activities, timing of contribution, and work intervals. In MediaWiki, this function also includes the possibility to roll back to earlier versions and to compare differences between versions. This work focuses on students' actions carried out on the wiki as they performed collaborative writing activities in groups. The following research questions guided the study:

(a) What were the work distribution and level of contribution among the students in the groups?
(b) What were the types of activities that the students performed on the wikis?
(c) What was the timing of contribution and work intervals?
(d) What were the issues raised in the discussion page of the wikis?
(e) What are the pedagogical and technological implications of using wikis to perform collaborative writing activities in teacher education?

11.3 Theoretical Background

Collaborative learning results in students working together as a team to solve a problem (Johnson and Johnson 1989). Through collaboration, students create a social learning environment that is more powerful than the addition of individual work (Thompson and Ku 2006). In this regard, Witney and Smallbone (2011) pointed out that student groups "can achieve more collectively than individuals" (p. 102). Collaborative learning is associated with the social-constructivist learning theory (Vygotsky 1978), which claims that learning occurs as learners improve their knowledge through collaboration in authentic contexts. Collaborative writing is a specific form of collaborative learning. It aims at transforming a text by multiple students into a collective document (Bradley et al. 2010; Tal-Elhasid and Meishar-Tal 2007; Trentin 2009). The collective production of the document involves all aspects of writing: content editing and structuring, formatting, and language issues (Chao and Lo 2011). Students need to coordinate their efforts to produce the document collectively. Collaborative writing is primarily a matter of editing and improving each other's contributions to the collective document, as well as providing feedback, suggestions, and comments by means of peer assessment (Bradley et al. 2010; Tal-Elhasid and Meishar-Tal 2007). The benefits of collaborative writing are considered as positive for the learning process. According to McConnell (2006; cited in Witney and Smallbone et al. 2011), collaborative writing facilitates critical thinking, enables the sharing of information, helps to acquire collaborative skills, and gives students an opportunity to practice group discussion. Collaborative writing also provides opportunities to acquire academic reading and writing skills and helps to practice literature review (Kim et al. 2009; Trentin 2009). Likewise, Yarrow and Topping (2001) reported that students writing collaboratively are more effective than those working individually. However, putting students together does not automatically result in collaboration. Rather, as Violet and Mansfield (2006) (cited in Witney and Smallbone (2011), p. 103) pointed out, students "may be inclined to divide the task into independent subtasks that are merely assembled and submitted." Hence, when analyzing students' actions carried out on the wiki, it is important to distinguish between collaborative and cooperative work. These are often used interchangeably, but there is a clear distinction between them (Witney and Smallbone 2011). Collaboration is seen as an activity where participants coordinate their efforts to solve a problem collectively (Tal-Elhasid and Meishar-Tal 2007; Resta and Laferrière 2007). In contrast, cooperation is defined as a work where participants divide a task into subtasks and work independently from each other (Tal-Elhasid and Meishar-Tal 2007). Clearly, cooperation is associated with the division of work between participants performing a joint activity, while collaboration involves the "mutual engagement of participants in a coordinated effort to solve the problem" (Dillenbourg et al. 1996, p. 190, cited in Judd et al. (2010)). Cooperation "usually implies either splitting up the work or solving subtasks individually and combining the results into a final product. In contrast, collaboration can mean a coordinated attempt to solve and monitor a problem together, with perhaps some division of labour on aspects of the problem" (Scanlon 2000, pp. 464–465, cited in Judd et al. (2010)).

11.4 Literature Review

The concepts described in the previous section are used to review the research literature related to collaborative writing and the extent to which students collaborated when they used wikis. According to the research literature, wikis have been used to support a variety of educational purposes associated with collaborative learning (Chao and Lo 2011; Meishar-Tal and Gorsky 2010; Parker and Chao 2007; Thomas et al. 2009; Trentin 2009). For example, teachers have used wikis for collaborative curriculum design, course content authoring, and group project (Leung and Chu 2009; Matthew and Callaway 2009; Mindel and Verma 2006). Other examples of wiki in education are research project and literature review (Su and Beaumont 2010); glossaries, manuals, textbooks, discussion and review, and formal and informal assessments (Hughes and Narayan 2009); building knowledge bases (Tetard et al. 2009); social negotiations (Vratulis and Dobson 2009); enhancing student interactions (Lund and Smørdal 2006); and distance education (Jones 2010). Most of these studies are based on participants' subjective perceptions of wikis. Recently, a growing number of studies have drawn on the log data generated by wikis (Judd et al. 2010; Leung and Chu 2009; Santos et al. 2010). In contrast to subjective perceptions, data logs permit a quantitative analysis of students' contributions to the wikis.

Experiences reported in previous research studies show that wikis have the potential to enhance group-based learning, and evaluations of wiki implementations in education tend to be positive regarding collaborative learning and writing (Huang and Nakazawa 2010). However, a number of difficulties must be overcome, before wikis can be used to foster genuine collaborative writing. Karasavvidis (2010) reported on a number of studies about students' resistance against wikis and their preferences for individual work over collaboration. Carr et al. (2007) pointed out that some students are not motivated to use wikis for online course work. Elgort et al. (2008) indicated that students believed that they could have accomplished the task better on their own, despite the potentialities of wikis to facilitate collaboration among students. On the other hand, even though students do see the potentialities of wikis, their use does not automatically guarantee collaboration (Ma and Yuen 2008). Likewise, a serious problem seems to be the limited student contribution to the wiki. In this regard, Cole (2009) reported that after the first half of the semester, the students had not contributed to the wiki at all. Likewise, Ebner et al. (2008) also indicated that none of the students involved in wiki tasks created new pages, modified existing pages, or rephrased exiting content over an entire semester. Similarly, Britcliffe and Walker (2007) reported on students' unwillingness to engage effectively in collaboration because they do not like to change others' work. Furthermore, Arnold et al. (2009) pointed out that students were more concerned with adding content to existing pages and rarely revise the content edited by fellow students. Lund and Smørdal (2006) also found that students did not like to rewrite or modify their own work or peers' contributions to the wiki. Moreover, Minocha and Thomas (2007) highlighted that that peer reviews were not perceived as being positive by some students. The research literature also reports on the inappropriateness of existing wiki tools for collaboration, because there is a need to support the discussion aspects of wikis with more usable tools (Minocha and Thomas 2007). Another potential drawback of wikis is that they allow a user to change the content of a Web site. This raises questions of copyright (Heafner and Friedman 2008). Forte and Bruckman (2007, cited in Judd et al. 2010) reported that students have the tendency to postpone important parts of the wiki as the project deadline approached. Finally, Carr et al. (2007) pointed out that a minority of students perform much of the wiki activities, while other students in the same group do not contribute at all or contribute minimally.

11.5 Research Methodology

This chapter provided an overview of the theoretical background for the use of wikis for collaborative writing. A review of the literature on positive and negative points of using wikis as collaborative learning tools is also undertaken. The following case study examines the extent to which wikis support collaborative writing in teacher education. First, the characteristics of the participants are described, followed by the learning tasks that the participants have to perform to produce a wiki. Then, the overall procedure for developing wikis is presented. Finally, data collection methods and the main categories used to analyze the students' collaborative writing activities are specified.

11.5.1 Participants

Eight graduate students (three males and five females, six aged 22–28 years, two >28 years), enrolled in a Web 2.0 technology course, participated in the study. None of the students were involved in the development of wikis before taking the course. Most students were familiar with Wikipedia, but they had no prerequisite knowledge in Web 2.0 tools or collaborative writing. The students knew each other and worked together in one or another form. The teacher divided the students into three self-selected groups based on their choice of the wiki topic. The groups were then involved in the construction of wikis to support collaborative writing. One group was composed of four members (two males and two females) and two groups of two members, respectively. Six students had background in teacher education. Two were enrolled in information systems studies, but they were introduced to issues related to teacher education, pedagogy, and learning paradigms.

11.5.2 Learning Tasks

The learning tasks involve specific statements and assignments that the students had to complete when they perform collaborative writing activities using wikis. Firstly, the wikis should have a large content scope, but should not exceed 7,000 words in length. The wikis must provide more than rudimentary information about the topic. Some pages may contain suggestions for quality improvement that provides the seed for a more thorough wiki article. Secondly, the design of the wikis should follow general guidelines for writing articles, including layout, formatting, style, and use of references. Students should use basic wiki functions to edit content, upload files and images, and discuss issues related to the wiki topics using the discussion page. Thirdly, the wikis should be designed in such a way that they are self-explaining to the users. They should offer information about the wiki topic that is relevant to the users. Finally, students should have access to wiki resources that comprise good examples of wiki articles in teacher education. Parts of these wikis may be adapted and reused with slight modifications. The students were introduced to the wiki resources to motivate them and ensure their appropriate reuse.

11.5.3 Procedure

To support collaborative writing, six stages were scheduled for the students to complete their work and for the teacher to supervise the students' progress. The six stages were information gathering, wiki architecture, page design, collaborative wiki development, cross-page linking, quality assurance and integration of the pages, and overall evaluation. The reason for using six stages is that wiki-based collaborative writing follows the one used for Web-based learning systems (Hadjerrouit 2010a). Furthermore, an evolutionary approach based on rapid prototyping was chosen for the development process and associated collaborative writing activities (Shih et al. 2008). Rapid prototyping helps to quickly generate an initial written text that can be improved, changed, and modified collaboratively through incremental revisions.

11.5.4 Data Collection and Analysis Methods

Data collection relied on the data logs generated by the wikis. The logs kept track of the actions carried out on the wikis by each member of the groups. These are chronologically listed by date, author, and changes made in the text. In line with (Hadjerrouit 2012), data analysis consisted in classifying the actions in three groups:

- Distribution of work and level of contributions made by each student
- Types of activities performed by each group
- Timing of contribution and work intervals associated with each group

The students' actions were then analyzed quantitatively to assess the extent to which the students worked collaboratively. Taxonomies for analyzing students' actions have been proposed by a number of researchers (Leung and Chu 2009; Meishar-Tal and Gorsky 2010; Pfeil et al. 2006). In line with (Hadjerrouit 2012), the following categories guided the analysis of students' actions:

- Modify content
- Add content
- Delete content

- Fix link
- Add link
- Delete link
- Formatting
- Grammar, style, and spelling

Since collaboration writing is defined as an activity where participants coordinate their efforts to edit a document collectively, it follows that some categories are more important than others in terms of collaborative activities. In other words, collaborative writing is first of all a transformation of an initial text into a collective document by modifying, deleting, and adding content. Moreover, genuine collaborative writing is more a matter of modifying others' contributions to the wiki than adding and deleting content. It follows from these considerations that "modify content," "delete content," and "add content" are more important than "fix link," "delete link," and "add link," followed by grammar, style, spelling, and formatting. This does not imply that the last mentioned categories are not relevant for collaborative writing. Finally, in addition to the data logs, this work also analyzes the issues raised by the students in the discussion page of the respective wikis.

11.6 Findings

11.6.1 Distribution of Work and Level of Contribution

Table 11.1 presents the distribution of work made by each member of the groups. For group 1, the percentage of contributions ranged from 39.56 to 16.40% of the total activities. One student contributed to almost 40% of the work, and the rest was distributed among the other students. In group 2, one student contributed to 87.43%. The same situation occurred in group 3, where one student contributed to 70.05%. The results indicate that the workload of groups 2 and 3 was not evenly distributed when compared with group 1, since most of the activities were done by only one student. Table 11.1 shows the level of contribution made by each student in the respective groups. The table does neither indicate the types of activities performed by the students nor show the level of collaboration among students. Thus, further analysis is required to gain more insight into the level of collaborative writing among the students and the types of activities performed on the wikis.

11.6.2 Types of Activities

The analysis of the data logs shows that the students carried out all types of activities (add, modify, and delete content; add, fix, and delete link; formatting; and gram-

Table 11.1 Distribution of work

	Group 1	Group 2	Group 3
Student 1	634 (39.56%)	292 (87.43%)	152 (70.05%)
Student 2	379 (23.64%)	42 (12.57%)	65 (29.95%)
Student 3	327 (20.40%)	–	–
Student 4	263 (16.40%)	–	–
Total	1,603 (100%)	334 (100%)	217 (100%)

Table 11.2 Types of activities performed on the wikis

	Group 1	Group 2	Group 3
Modify content	352 (13.88%)	38 (11.91%)	28 (7.22%)
Delete content	216 (8.51%)	31 (9.72%)	18 (4.64%)
Add content	426 (16.80%)	105 (32.92%)	68 (17.52%)
Fix link	67 (2.64%)	21 (6.58%)	12 (3.09%)
Delete link	19 (0.75%)	0 (0.00%)	2 (0.52%)
Add link	141 (5.56%)	52 (16.30%)	131 (33.76%)
Grammar, style, spelling	73 (2.88%)	17 (5.33%)	2 (2.52%)
Formatting	1,242 (48.98%)	55 (17.24%)	127 (32.73%)
Total actions	2,536	319	388

mar). Table 11.2 shows the activities performed by the groups in terms of number of actions and percentage.

Looking at the most important activities that the students performed, the following categories can be distinguished: add content, delete content, format content, and modify content that other students created. The most frequent activity in group 1 was formatting (48.98%), followed by add content (16.80%), and modify content (13.88%). Otherwise, the other activities were more or less insignificant. In group 2, the most frequent activity was add content (32.92%), followed by add link (16.30%), and modify content (11.91%). In group 3, the most frequent activity was add link (33.76%), followed by formatting (32.73%), and add content (17.52%). The distribution of the activities may be explained by the nature of the topic in terms of number of links, images, and colors needed to design the wikis. However, from the perspective of collaborative writing, the modification of existing content is an activity that the students did not carry out much as the findings clearly reveal when compared with the number of all contributions (13.88% in group 1, 11.91% in group 2, and 7.22% in group 3). From the perspective of adding content to exiting pages, the number of students' actions was slightly higher than the one registered for modifying content. In contrast, the number of actions for deleting content was rather low. Even though the fixing of links is considered as a collaborative activity, the number of total actions regarding those activities does not increase significantly.

As a result, the data logs provide clear evidence that the students tended to focus more on separate parts of the wiki than seeing the wiki as a collective task. Clearly, students were more apt to engage in cooperation rather than collaboration. Group members mostly worked on individual sections of the wiki and were more concerned with adding content and formatting the text. This reduced the opportunity to produce the wiki content collectively. There were simply few occasions when the groups worked on the same sections of the wiki by revising and rephrasing substantially each other's work. This cannot be considered as genuine collaborative writing.

11.6.3 Timing of Contribution and Work Intervals

As stated above, the wikis were carried out using a rapid prototyping approach to speed up the development process. The student groups were supposed to create a number of prototypes associated with collective texts that need to be gradually improved collaboratively. The student groups had four deadlines, one for each prototype during the development process. Table 11.3 shows the timing of contributions and work intervals. The table shows that all group worked much as the last deadline approached and did not follow the schedule assigned throughout the project period from January 19 to May 14. This was particularly true for groups 1 and 3.

11.6.4 Discussion Log

An analysis of the information found in the discussion log shows that the issues discussed by the students can be related to three categories:

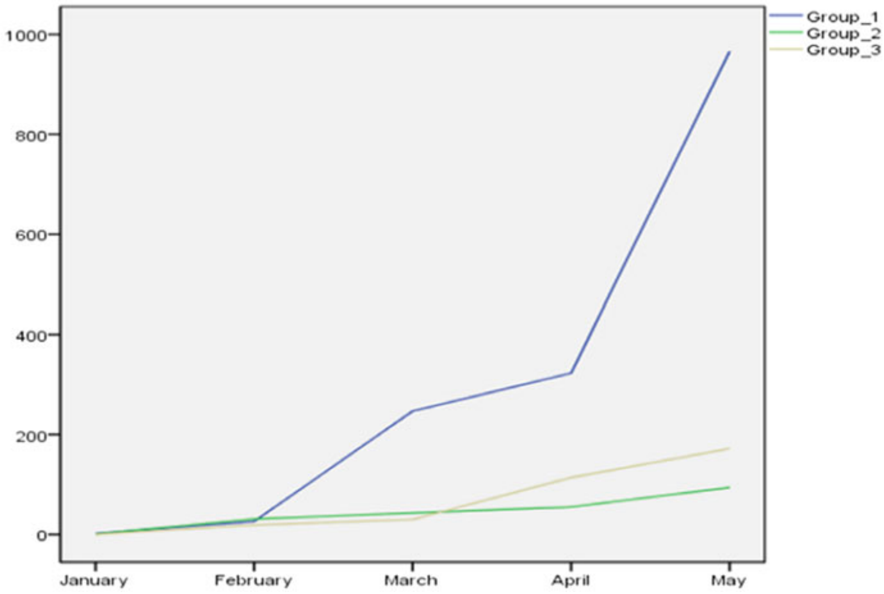
- Online written discussion and face-to-face communication
- Online written discussion and communication via Web 2.0 tools
- Usability issues

11.6.4.1 Online Written Discussion and Face-to-Face Communication

Most students felt the need to engage in some form of synchronous communication to exchange their ideas and share their concerns, because MediaWiki does not provide an appropriate forum for discussion. Most students highlighted the benefit of using the discussion page in conjunction with face-to-face communication. There were several responses to this issue of which the following are representative:

> We have had several face-to-face meetings where we worked together and discussed the wiki task.
>
> It is difficult to measure the degree of collaboration, because there have been much face-to-face discussions between the students. Such discussions are not easy to transmit by means of the discussion page.

Table 11.3 Timing of contribution and work intervals



	January	February	March	April	May
Group 1	2	26	247	323	966
Group 2	1	31	43	55	94
Group 3	0	19	30	114	172

> You can collaborate by discussing. If this is the most ideal way to collaboration is another matter. It depends on the number of the students in the group. To some extent the discussion page fosters collaborative learning, but it is best to vary with group meeting, when using the discussion page.

11.6.4.2 Online Written Discussion and Communication via Other Web 2.0 Tools

Besides face-to-face communication, some students indicated that the discussion page can be used in combination with other Web 2.0 tools, such as Facebook and Google Docs, and eventually supplemented by traditional channels for communication, such as emails and phone.

> The discussion page of the wiki was easy to use, but we have also included some discussion issues in a joint document we created in Google Docs. Here we included the work plan for the wiki, because this was more practical to do there. The themes we have discussed were, among other things, links and layouts for the wiki.

In addition to several meetings we have had periods where we have been working independently of each other, but kept in touch through other Web 2.0 tools, such as MSN, Facebook and discussion page on MediaWiki.

11.6.4.3 Usability Issues

The issues reported by the students referred to the editor being used for collaborative writing and the usability problems it created such as concurrent updating, placing of images and figures, and discussion treads. Some of representative comments were:

We have been quick to use the discussion page, but it still feels a bit "forced". We experienced that the discussion page is too poor when used as a collaborative forum. Name and date should automatically come up.

We have tried to use the discussion page of the wiki, but this has not been the best aid for collaboration for us, since we only have been two of the group and worked closely. (…). We must write down the date and the purpose of the comments. This is perceived as cumbersome, and we found that discussions may be discontinuous.

There are no alerts/messages when you (…) change the article. The discussion page is like a wiki article and it is easily done that it just becomes a jumbled text, because there is no standard format. Anyone can enter text on the discussion page. It gives neither the name, time nor the date when someone writes down a new comment.

We have tried to spend a lot of time to make the wiki user-friendly. Should teachers be met by large blocks of text can quickly cause that they choose not to use the wiki because there is much text that is hard to find. Different colors for different subjects also enable users to quickly see that they come into the new subject, and they can easily keep track of the wiki

11.7 Discussion

The findings suggest several pedagogical and technological implications for the use of wiki for collaborative writing in teacher education.

11.7.1 Pedagogical Implications

Wikis have been promoted as tools that potentially support collaborative writing. Yet, the research literature has identified a number of problems related to the use wikis as collaborative writing tools. In line with this research, the findings indicate that the students' collaborative writing activities were carried out in a relatively simple and uncritical way. Formatting was the most frequent activity that the students performed, followed by adding content to existing pages. Other activities were deleting small portions of the text, as well as adding, deleting, and fixing links.

Otherwise, grammar, style, and corrections of the text were insignificant. Even though these activities cannot be ignored when writing collective texts, they cannot be considered as genuine collaborative writing. Indeed, if collaborative writing is seen as an activity that deeply and substantially transforms a text into a collective document, the findings reveal that the students did not engage in genuine collaborative writing activities, since modifying others' contributions was not the most frequent activity. The distribution of work among the students and the level of contribution also confirmed that the wiki construction process was mostly done by only one student, except for group 1 where the workload was relatively more evenly distributed among the students. Likewise, the timing and work intervals also show that the most part of the work was done only some days before the delivery of the wiki projects. This is not surprising given the students' tendency to postpone their work until the last minute (Leung and Chu 2009). All group worked much as the last deadline approached and did not follow the schedule assigned throughout the project period. This factor clearly undermined the students' opportunities to collaborate and discuss with their peers. Another piece of evidence, which suggests that the level of collaborative writing was low, is provided by the analysis of the issues raised in the discussion page. These focused mostly on technicalities of the wikis rather than reflecting on the content. The level of engagement with the wiki content was simply too low to expect a coordinated attempt to develop wikis in collaboration. Rather, it appears that the students were more cooperative rather than collaborative by splitting up the wiki task in subtasks among themselves and combining their work into a final wiki.

There are a number of possible explanations for the relatively low level of collaboration. Firstly, one explanation is the students' lack of collaborative skills and experience with collaborative writing. While MediaWiki possesses a number of features that may facilitate collaboration, it does not necessarily follow that the tool brings about an appropriate level of collaboration and group interaction, unless students possess collaborative skills (McLoughlin and Lee 2007). Clearly, MediaWiki alone does not guarantee that students will work collaboratively to perform writing activities. Another critical factor might be the students' lack of preparation and familiarization with the wiki tool (Minocha and Thomas 2007). In addition, the close integration of learning tasks and assessment goals, whether and how the wikis will be assessed individually or in groups, and which assessment items are considered may motivate students to effectively engage in meaningful collaborative writing (Nokelainen 2006). The absence of these factors may have hampered the students' motivation to fully collaborate.

Secondly, another possible explanation could be that some students were extremely dominant to carry out actions on the wiki (Meishar-Tal and Gorsky 2010). Indeed, two students in two groups carried out 70–80% of the actions, including all activities ranging from adding content and links, modifying and deleting content, to grammar. This behavior is not surprising, and it is consistent with previous research that analyzed participant attitude in Wikipedia (Tapscott and Williams 2007, cited in Meishar-Tal and Gorsky 2010).

Thirdly, true collaborative writing may be a real challenge for any student as it is demanding in terms of efforts and time (Thompson and Ku 2006; Violet and Mansfield 2006; Wheeler and Wheeler 2009; Witney and Smallbone 2011). This may explain why students were more inclined to cooperate than collaborate by dividing the writing task into independent subtasks that are combined to a final product. Even though cooperative writing may help students to achieve some of the learning goals, it does not benefit from group interaction, in contrast to collaborative writing. According to Violet and Mansfield (2006), learning may be minimal when collaborative writing is limited to pairs and does not take advantage of the dynamics of group members, in particular when support and opportunities for teacher supervision are limited. From these considerations, it appears that genuine collaborative writing is difficult to achieve, unless students possess critical thinking skills to judge the information posted by other students (McLoughlin and Lee 2007). Otherwise, collaborative writing cannot happen, and as result, students will just accumulate information in the wiki as the data logs clearly show.

Fourthly, the dominant learning paradigm in education relying on the behaviorist learning paradigm is another obstacle to collaborative writing. Behaviorism is incompatible with the wiki philosophy based on collaborative learning. In this regard, Karasavvidis (2010) suggested that the low level of wiki-based collaboration is to a large extent determined by the behaviorist learning paradigm and concluded that collaborative writing cannot develop fully, unless the existing learning paradigm changes radically. This implies that wiki affordances cannot be realized without a shift from behaviorism to social constructivism. Likewise, wiki-based collaborative writing will not work successfully unless students are accustomed to social-constructivist learning and given more time and opportunity to familiarize themselves with collaborative practices. Moreover, a change of the learning paradigm requires that teachers change their role from transmitters of knowledge to facilitators of collaborative writing. Likewise, Scardamalia and Bereiter (2006) recommend teachers to play a critical role when they design tasks for collaborative writing.

Finally, the wiki discussion page in its present form is not the best tool that facilitates written discussion and dialogue. Face-to-face communication is still important to the learning process, because student collaboration in a wiki-based learning environment is not just a matter of online interaction, but it is a social relation as well. Clearly, the wiki discussion page cannot completely replace human dialogue and social relationships in collaborative writing, and important decisions still need to be discussed face-to-face. As a result, wikis still need to be used in conjunction with other means of communication. In line with the research literature (Weber 2008; Witts 2008), this work also seems to confirm that the blended pedagogical model that combines wiki technology with face-to-face interactions may provide the most beneficial scenario for communication. Also, Grant (2006) pointed out that the use of wikis needs to be centered around social and cultural practices of collaborative writing to take advantage of wiki affordances.

11.7.2 Technological Implications

The findings reveal that a range of technological problems should be solved in order to support genuine collaborative writing with wikis. Firstly, the discussion page needs to be improved to follow a discussion tread, that is, the chain of written comments or opinions exchanged among participants. Discussions need to be linked by the name of the contributor and time of contribution and in the sequence in which they were developed by the participants. Name and time should be generated automatically without the explicit intervention of the students. Otherwise, the discussion page cannot keep a sense of order on the information exchange. Secondly, another technological problem is the lack of a locking function to avoid the problems of simultaneous and concurrent editing. A page that is currently used by a student should be locked for usage by other students. Finally, in line with (Thomas et al. 2009), the lack of a WYSIWYG editor, found in other authoring tools, also negatively influenced students' collaborative writing.

11.8 Conclusions

Even though the findings are in line with previous research work, this study is not representative for a larger population of students, because it used a small convenience sample, with participants from one course only. As a result, it cannot be generalized to the total population of students taking wiki courses in various educational contexts. Hence, there is a need for replication studies with a larger population of students to confirm the findings. Nevertheless, some conclusions can be drawn from the study for the successful implementation of wikis as collaborative writing tools in teacher education. Firstly, the findings reveal that wikis alone cannot foster collaborative writing, unless pedagogical and technological factors are taken into account. These factors are necessary to ensure a successful implementation of wikis for collaborative writing. Secondly, since wikis are underpinned by the collaborative learning theory, it becomes necessary to adopt a pedagogy based on social-constructivist principles that enable students to create wikis collaboratively through social interactions, information sharing, and critical reflections. A social-constructivist approach to wikis includes teachers as designers of collaborative activities (Lund and Smørdal 2006). Then, understanding the fundamental difference between cooperation and collaboration is an important prerequisite to better prepare students for collaborative writing practices, teamwork, group discussion, and peer assessment. Moreover, students need to be made explicitly aware of the affordances of wikis to support collaborative writing. Likewise, students are required to critically consider the limitations, constraints, and drawbacks of wikis from a technological point of view. Finally, wikis need to be used in conjunction with other Web 2.0 technologies, for example, Google Docs, and conventional means of communications, such as emails, phone, and face-to-face meetings, on the other hand. These communication channels are still indispensable in a wiki-based learning environment. Their impact on learning and motivation cannot be underestimated, since students prefer different learning styles and multiple approaches to learning (Hadjerrouit 2010b). These issues will be explored and discussed in more details and depth to improve collaborative writing with wikis. Future work will also be undertaken with larger and diverse student groups to ensure more reliability and validity of the findings.

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Part IV
Virtual Worlds and Game-Based Informal and Formal Learning

Chapter 12
Effect of Virtual Exploratory Learning System

Hiroshi Matsuda and Yoshiaki Shindo

12.1 Introduction

There are several types of educational contents using computer that have been reported (Kirriemuir and Mcfarlane 2004; Egenfeld-Nielsen 2004; Prensky 2003). And considering teaching the theory, principle, or mechanism of science to junior high school students, the most effective teaching materials may be actual videos. However, actually it is difficult to take pictures of invisible science phenomena. Moreover, the production cost of the actual video may be too large depending on the subject, and it is difficult to produce interactive educational contents. Several types of science educational materials have been reported (Towne et al. 1993; Forbus and Feltovich 2001; Hirashima and Imai 2009). In Japan, one of the most representative science educational materials would be "Science Network" (Ricanet 2006) produced by the Japan Science and Technology Agency. Science Network has a lot of actual video libraries. They are very effective to teach the principles of science. But most of them are not interactive teaching materials. It is difficult for teachers to edit or extend teaching materials on the spot when syllabus planning because it requires huge cost to modify actual videos. On the other hand, the 3D-CG animation using a virtual actor's speaking is very effective as an educational medium (Graesser and Hu 2001; Baylor 2001). But it usually takes a long time to produce 3D-CG animations. The most popular method to produce 3D-CG animations is to use some 3D-CG animation tools and a nonlinear video editing system. But it takes time to render 3D-CG animation frames and to integrate the animation, sound, music, and speaking; furthermore, it cannot construct an interactive system. Another way to make it is to use the programming language and some libraries (e.g., OpenGL). But its production cost also may be too much for educational contents. From this point of view, the System

H. Matsuda (✉) • Y. Shindo
Computer and Information Engineering, Nippon Institute of Technology, Miyashiro-machi, Minamisaitama-gun, Saitama, Japan
e-mail: hiroshi@nit.ac.jp; shindo@nit.ac.jp

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DOI 10.1007/978-1-4614-3329-3_12,

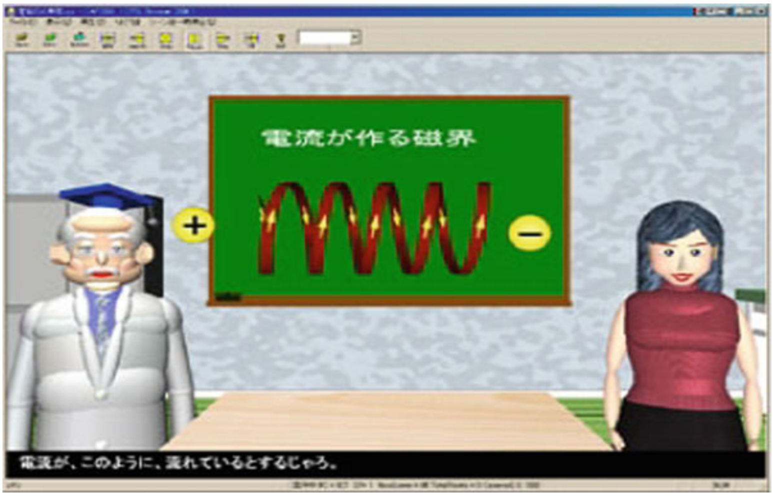

Fig. 12.1 Cyber Assistant Professor 2

Design Kit (SDK) libraries for human-shaped 3D-CG models were reported. "Jack" (Phillips and Badler 1988) was developed by the Pennsylvania University, which was a LISP language SDK for military application. "Alice" (Conway et al. 2000) is a 3D graphics programming environment developed by Carnegie Mellon University. MPML (Okazaki et al. 2000) is a hypertext for the Web presenter developed by Tokyo University. TVML (Hayashi et al. 1999) is a script language that creates a real-time CG animation of the news show automatically. However, as we have reported (Matsuda and Shindo 2008, 2009), these systems are not suitable for developments of teaching materials. To reduce the cost of producing 3D-CG educational contents and improve the capability of the educational system, we have developed e-Education system named Cyber Assistant Professor 2 (CAP2) and the exclusive scenario language named Cyber Person Scenario Language 3 (CPSL3) to write a scenario of 3D-CG animation. Furthermore, we have developed the new function named Virtual Exploratory Learning (VEL) service in CAP2 system. This chapter describes the summary of CAP2 and CPSL3 and then describes the detail of VEL service.

12.2 Cyber Assistant Professor

We have developed e-Education system named Cyber Assistant Professor 2 (CAP2) (Matsuda and Shindo 2008, 2009). It includes virtual actor(s), a 3D-CG stage, and many kinds of stage parts (3D-CG shaped models, photograph panels, or text panels). Figure 12.1 shows the window of CAP2 e-Education system. Virtual actor is a software robot of human shape based on 3D-CG technology and text-to-speech synthesis (TTS). A virtual actor speaks English or Japanese by TTS with facial expressions and body actions.

Table 12.1 Main <TAG> command of CPSL3

Tag	Function
<STAGE>	Creates the background stage using 3D-CG models and pictures
<PERSON>	Creates the cyber person(virtual teacher and virtual student)
<SPEAK>	Speaks the text string
<FACE>	Applies the facial expression in specified time transition code
<SCRIPT>	Displays the subtitles under the window
<ACTION>	Plays the body action in specified time transition code
<MOTION>	Plays the body performance in specified times and speed
<PARTS>	Creates the stage parts
<MOVE>	Moves the stage parts
<SOUND>	Plays the sound effect with WAVE file
<CAMERA>	Moves the viewing camera in specified frames
<SCENARIO>	Links to the external animation scenario file
<REQUEST>	Defines the selectable ANSWER target
<ANSWER>	Defines the entry point of <REQUEST> blocks

To reduce the production cost of CAP2 animation and improve the capability of the educational system, we have developed the exclusive script language named Cyber Person Scenario Language 3 (CPSL3) (Matsuda and Shindo 2008, 2009). To describe a 3D-CG interactive animation scenario easily, we designed the <TAG> based script language similar to HTML for the Web page. The way to make a scenario is just to put an appropriate text string between a pair of <TAG> markers (named body text). Some <TAG> markers include the option switches to specify the system mode or set the state variables. CPSL3 coding can be edited by using the text editor or the word processor. CPSL3 has more than 40 tags. Table 12.1 shows the main tag commands of CPSL3. CAP2 e-Education system converts CPSL3 scenario file to the real-time interactive 3D-CG animation. The details of CPSL3 are referred in the references (Matsuda and Shindo 2008, 2009).

12.3 Cyber Assistant Professor

After we have tested the CAP2 education system in junior high school for 3 years, we have noticed that there would be some problems in our educational system. Although 3D-CG animation of the Virtual Science Experiment has stimulated student's motivation and increased their interests, we cannot say their attained grade in virtual experiment is very good. In the case of "Let's make the DC motor," 32% of students were not able to design the working DC motor, and in the case of "Let's create the typical Gas," more than 50% of students could not achieve the correct answer except the hydrogen gas creation. We thought that this situation might be caused by lack of knowledge of materials (electric parts or chemical materials,) in detail. To improve these problems, it is necessary to give students the essential knowledge of materials before they begin to choose them in virtual experiment. However, there would be differences in necessary knowledge among students. To improve this problem, we have developed the **Virtual Exploratory Learning** (**VEL**), which inserts the VEL time period during the progress of experiment (named **VEL service**). In VEL service, each student can search for necessary knowledge like the explorer.

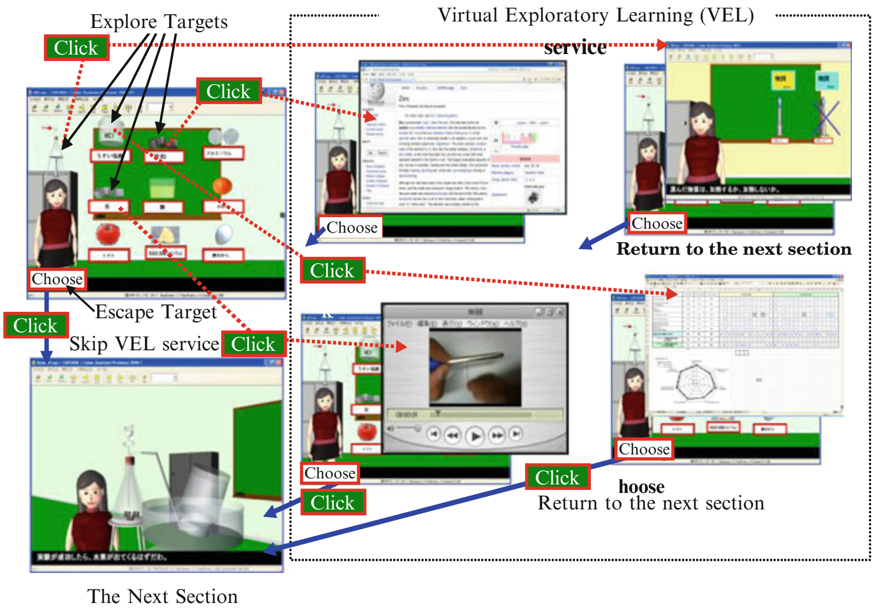

Fig. 12.2 The flowchart of the student's operation in VEL service

Figure 12.2 shows the flowchart of the student's operation during **VEL service**. Students can click the **ESCAPE target** if he/she does not need more knowledge of materials in details and go to the next section of scenario. But if the student cannot choose the correct answer due to a lack of knowledge of materials, he/she can click any EXPLORE target to get the hint information inserted beforehand in the scenario. **EXPLORE target** is also stage parts which can be defined by new CPSL3 tag commands (see Table 12.2). We have developed five kinds of new target which are **ESCAPE target**, **INTERNET target**, **MOVIE target**, **EXPLAIN target**, and **SHELL target**.

The <EXPLORE> tag command pauses the progress of CAP2 animation scenario and defines the ESCAPE target to return to the animation scenario. Then the Exploratory Learning period is started and continued until the student clicks the ESCAPE target. The <EXPLORE> tag command must be coded lastly. The <INTERNET> tag command defines the INTERNET target with the specified URL. If a student clicks it in VEL period, Internet Explorer opens the specified Web page as hint information. The <MPLAYER> tag command defines the MOVIE target with the specified filename. If the student clicks it in VEL period, the media player is started to play the specified movie as hint information. The <EXPLAIN> tag command defines the EXPLAIN target with the specified filename of CPSL3 scenario file. If the student clicks it in VEL period, another CAP2 system is started simultaneously to play the specified 3D-CG animation as hint information. The <SHELL> tag command defines the SHELL target. It is a little difficult to define the SHELL target, but it is an extraordinary and powerful function. <SHELL> tag command can define the entry point of arbitrary Windows application software such as word processor, PDF reader, PowerPoint, or other

Table 12.2 The new tag commands for VEL service in CPSL3

Tag command	Function
<EXPLORE>	Defines the ESCAPE target to return to the animation scenario and enter the Virtual Exploratory Learning service
<INTERNET>	Defines the INTERNET target to open the specified Web page
<MPLAYER>	Defines the media player target to play the specified movie
<EXPLAIN>	Defines the EXPLAIN target to execute another CAP2 system simultaneously
<SHELL>	Defines the SHELL target to execute any kind of windows application

streaming video players (e.g., RealPlayer, QuickTime). If the student clicks it in VEL period, some Windows applications are started as hint information.

The typical scenario coding to insert the VEL period might be as follows.

From Target1.tdm to Target4.tdm and Escape1.tdm are 3D-CG stage parts where the student can click in the VEL service. The targets do not limit to the text panel and are able to specify all kinds of 3D-CG shaped models. Of course, any number of EXPLORE targets can be defined.

```
<INTERNET FILE=”Target1.tdm” PARAM=”http://ja.wikipedia.org/
    wiki/%E5%A1%85”
POSITION=”-500.0, 600.0, -2000.0” ROTATION=”0.0, 0.0, 0.0”
    SCALE=”1.5, 1.5, 1.5”>
<MPLAY FILE=”Target2.tdm” PARAM=”DC-motor.avi”
    POSITION=”-100.0, 600.0, -2000.0” ROTATION=”0.0, 0.0, 0.0”
SCALE=”1.2, 1.2, 1.2”>
<EXPLAIN FILE=”Target3.tdm” PARAM=”Hint1.cps”
    POSITION=”200.0, 600.0, -2000.0” ROTATION=”0.0, 0.0, 0.0”
SCALE=”1.0, 1.0, 1.0”>
<SHELL FILE=”Target4.tdm” PATH=”C:\Program Files\Microsoft Office\
Ofice11”
    COMMAND=”Excel.exe” PARAM = “Data1.xls”
    POSITION=”800.0, 600.0, -2000.0” ROTATION=”0.0, 0.0, 0.0”
SCALE=”1.5, 1.5, 1.5”>
<EXPLORE> FILE=” Escape1.tdm”
POSITION=”-1000.0, 700.0, -1500.0” ROTATION=”0.0, 0.0, 0.0”
    SCALE=”1.8, 1.8, 1.5”>
```

12.4 Virtual Science Experiment with VEL Service

In order to investigate the effect of Virtual Science Experiment with VEL service, we have developed science teaching materials for junior high school students based on the interactive 3D computer graphics animation with CAP2 education system. They are “Electric Circuit and Magnetic Force” and “Let’s create Gas.” Virtual

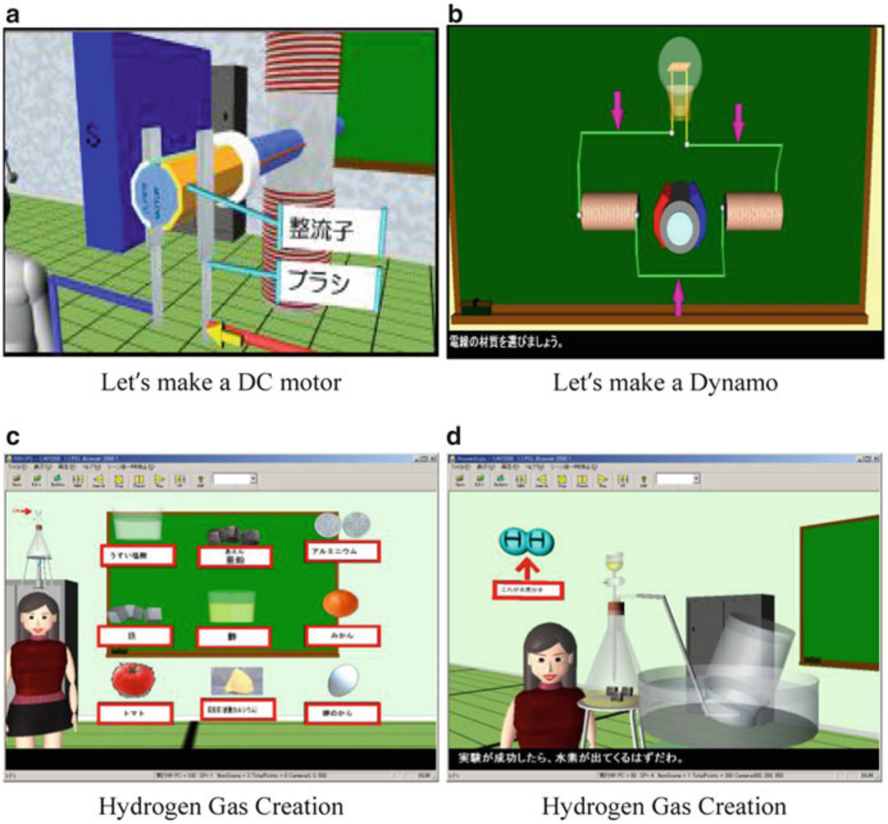

Fig. 12.3 Example pictures of Virtual Science Experiment

Science Experiment includes six subjects. We have developed these scenarios by two teachers and five students. Figure 12.3 shows example pictures of the Virtual Science Experiment and Table 12.3 shows the contents.

12.5 Results of Virtual Science Experiment

12.5.1 Rate of Correct Answers in the Virtual Experiment

In order to investigate the VEL, we have done the virtual experiment twice in a computer room at a junior high school. We have brought 30 high-performance personal computers in the computer room. There were eight staff that included two teachers, and there were also two junior high school teachers. Totally 60 students tried to challenge the virtual experiments with VEL service, which were “Let’s make a DC motor by choosing the electric parts” and “Let’s create typical Gas by

Table 12.3 Contents of Virtual Science Experiment

Subject	Interactive virtual experiment	Number of CPSL3 lines
Electric circuit and magnetic force	Let's make a DC motor	1,864
	Let's make an electric dynamo	2,020
Let's create gas	Hydrogen gas creation	1,657
	Carbon dioxide gas creation	1,426
	Oxygen gas creation	2,306
	Ammonia gas creation	1,715

choosing experimental equipment and chemical materials." Figure 12.4 and Table 12.4 show the students in this experiment.

After the virtual experiment with VEL service in each time, we have collected 60 student's logging data of choosing processes which were saved by CAP2 automatically. Figure 12.5 shows the results of "Let's make a DC motor." In this experiment, about 54% students have used the VEL service. And the arrows in Fig. 12.5 indicate the decreases of the incorrect choice that students made. For example, in scene 1, among students who have used VEL service, the percentage of incorrect answers was from 44 to 22%. Figure 12.6 shows the results of "Let's create the typical Gas." In this experiment, about 50% students have used the VEL service. And the arrows in Fig. 12.6 indicate the decreases of the incorrect choice that students made. For example, in scene 1, among students who have used VEL service, the percentage of incorrect answers was from 50 to 37%.

12.5.2 Comparison Between Results with VEL and Without VEL

In order to investigate the effect of VEL service, Fig. 12.7 shows the comparison between the results of the experiment with VEL service and without VEL service that we have done last year. The subject of the experiment was "Let's make a DC motor by choosing electric parts." The percentage of students who were able to design high-speed and middle-speed motors has increased from 52 to 68%. And the percentage of "Failure" has decreased from 32 to 16%.

12.5.3 Impression of VEL Service

After experiments, students were given a post-study questionnaire that asked about 5-grade impressions of Virtual Science Experiment. Figure 12.8 shows their 5-grade impression about the Virtual Science Experiment with VEL service for 60 students. Most of impression items were good. The average of all items achieved more than "4.0." Especially, the average of students who feel that "VEL service was a good guide" was "4.5."

Fig. 12.4 View of virtual experiment

Table 12.4 Situation of virtual experiment

	2010/12/9		2011/12/8	
Experiment time	90 min		90 min	
Grade	Second grade	Third grade	Second grade	Third grade
Boy	12	0	20	2
Girl	7	10	2	7

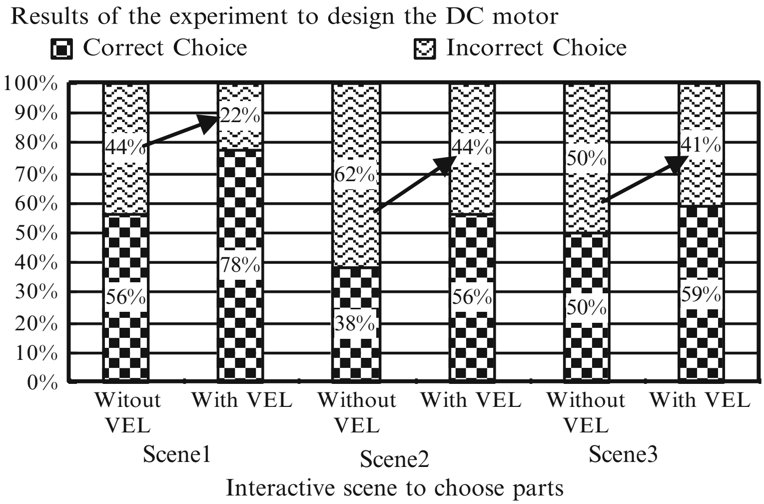

Fig. 12.5 The case to design the DC motor

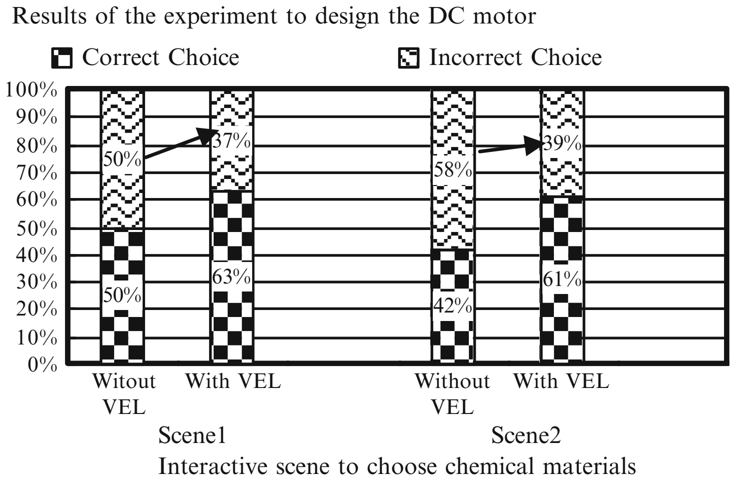

Fig. 12.6 The case to create the objective gas

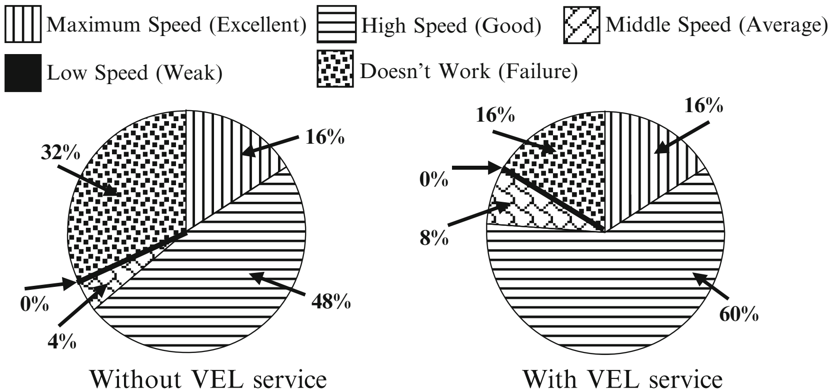

Fig. 12.7 Comparison between results with VEL service and without VEL service

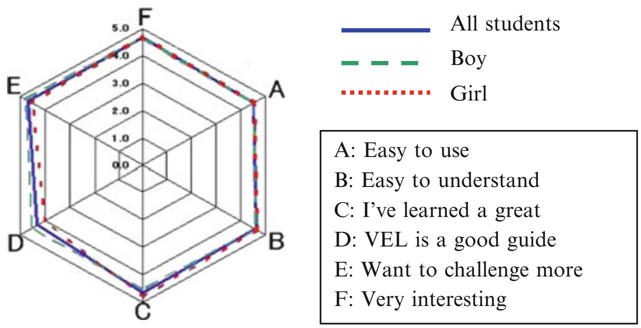

Fig. 12.8 Impressions of VEL service

12.6 Conclusion

This chapter described the details of Virtual Exploratory Learning (VEL). At first, it described the summary of our e-Education system named Cyber Assistant Professor 2 (CAP2) and the scenario language, Cyber Person Scenario Language 3 (CPSL3). We have developed new tag commands of CPSL3 to implement the VEL service in CAP2 e-Education system. And in order to investigate the effect of VEL service, we have developed the Virtual Science Experiment for junior high school students. Then we have analyzed the results of the logging data which the CAP2 e-Education system saved in the learning processes of Virtual Science Experiment with VEL service.

About 54% of students have used the VEL service, and the percentage of correct answers has increased. It was just as we had expected that over half of students lacked the knowledge of experiment materials in detail. They explored various kinds of EXPLORE targets delightfully in VEL service. We were impressed that there was no student who looked confused and paused in front of the computer. Finally, the impression of most of students was "good." From this point of view, we confirmed that the Virtual Science Experiment with VEL service is very effective for junior high school students.

In the future task, we will do the comparison experiment between virtual experiment and real experiment in the same subject.

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Chapter 13
Medical Educational Simulations: Exploring Reciprocity Between Learners' Skills, Attitudes, and Career Intentions: A Case Study of Simulation Education Research

Pamela Leonard, Elena Libin, Yuri Millo, and Alexander Libin

13.1 Introduction: Experiential Learning in Healthcare Simulation

The concept of experiential learning embraces traditional fields of study, such as cognitive psychology and experience-oriented pedagogy, as well as emerging areas of digital technology including medical simulations (MedSims), which provide interactive engaging platform for professional training and education (Armstrong 1979; SiTEL 2010). The Council of Residency Directors (CORD) at the American Board of Emergency Medicine has established the following recommendations for simulation in their statement (Chakravarthy et al. 2011):

1. Simulation is a useful tool for training residents and in ascertaining competency. The core competencies most conducive to simulation-based training are patient care, interpersonal skills, and systems based practice.
2. It is appropriate for performance assessment, but there is a scarcity of evidence that supports the validity of simulation in the use for promotion or certification.
3. There is a need for standardization and definition in using simulation to evaluate performance.
4. Scenarios and tools should also be formatted and standardized such that EM educators can use the data and count on it for reproducibility, reliability, and validity.

P. Leonard, R.N., M.S. (✉) • E. Libin, Ph.D. • Y. Millo, M.D.
SiTEL – Simulation and Training Environment Lab, MedStar Health, Washington, DC, USA
e-mail: pamela.leonard@email.sitel.org; elena.libin@medstar.net; yuri.millo@medstar.net

A. Libin, Ph.D.
MedStar Health Research Institute, Washington, DC, USA
e-mail: alexander.libin@medstar.net

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Increased awareness of student-centered approach is often limited by focusing on conceptualization of the approach with very little success in practical application development (Libin and Libin 2006a). As instructional designers strive to incorporate interactive methods to make professional education both meaningful and engaging by employing online courses, games, and medical simulations, the reciprocity, or co-influence, between learner's characteristics and new experiences during the training remains unexplored. It is not clear how cognitive prerequisites, such as attitudes and perception, impact the learning outcomes, in particular, professional intentions, and how they relate to learners' functional skills required by immersive educational technologies, such as MedSims.

The studies conducted at the MedStar Health address gaps in our understanding of the digital technology implications for both healthcare providers and healthcare takers focusing on developing role-playing video games (Libin et al. 2010), designing MedSims for professional skills training (SiTEL 2010), and utilizing online communication platforms to promote self-management of health conditions (Libin et al. 2011). The practical outcomes of the previous work included use of simulation to prepare for high-acuity, low-frequency clinical occurrences, use of simulation team training to improve the culture of safety in high-risk hospital environments, and development of haptic simulation devices.

The case study presented in this chapter explores the nature of experiential learning through express assessment focused on measuring learners' interaction with educational medical simulations in the context of functional skills, attitudes toward usefulness of MedSims in professional education, and career intentions.

13.2 Preparing the Healthcare Professional of Tomorrow

The use of advanced simulation and online technologies will increasingly play a role in preparing the healthcare professionals of tomorrow. Today, we have the ability to teach using authentic medical scenarios and authentic roles in "modeled" clinical settings. We can quickly organize and reorganize the learning space to accommodate team training, a diverse set of tasks, and real-world medical problems.

Although the job market continues to struggle, one industry is actually projecting growth: healthcare. The US Department of Labor expects a 22% increase in wage and salaried positions in the field by 2018, which is double the rate of growth for all industries combined (U.S. students… 2010). Despite the growing need for healthcare workers, the United States lags behind much of the world in its share of college graduates majoring in science and technology, ranking 29th of 109 countries in the percentage of 24-year-olds with a math or science degree. According to the Southwest Washington Workforce Development Council, there are many reasons for the healthcare shortage, but the most pressing issue appears to be recruitment (Addressing… 2003). This puts the United States in a compromising position. If unable to obtain people's interest in these fields, the impact be on economic stability could be significant, especially considering the economy is becoming more science and technology driven. So, what is preventing students from pursuing healthcare degrees?

In the University of the Sciences in Philadelphia's 2010 Healthcare and Science Jobs Survey, approximately 45% of 600 American teens, 13–18 years of age, reported that they were not considering degrees in healthcare or the sciences. Of these teens, 21% expressed that they were not good enough at these subjects in school, 19% did not feel prepared to pursue this type of degree, and 12% said that it would just be "too difficult" to obtain this type of degree. In addition, of the 45% not interested in healthcare degrees, 22% reported that their lack of interest stemmed from a lack of knowledge about the various healthcare jobs (U.S. students… 2010). Southwest Washington's study mirrored these findings, stating that one of their challenges is that "There is a lack of awareness in K-12 about the broad array of health care careers especially in areas beyond physician and nursing, such as medical office, imaging and laboratory occupations" (Addressing… 2003). Their study showed that this lack of awareness directly caused two other problems: if students were unaware about the various healthcare jobs, they were also unaware of the class work necessary to prepare for such a career, and the healthcare curriculum is different in each high school and does not cross over to community college programs.

The National Student Leadership Conference (NSLC), a collaborator on the presented case study, seeks outstanding high school students from around the world who demonstrate academic excellence and leadership ability. NSLC strives to provide a safe and supportive environment which encourages students to explore their academic and career interests while developing leadership skills essential for their success. The NSLC's goal is to provide innovative and challenging learning opportunities through hands-on simulations and workshops in conjunction with some of the nation's premier colleges and universities. The NSLC on Medicine & Health Care, located at the American University in Washington, DC (USA), uses an interactive approach to learning that provides students with an opportunity to immerse oneself in the challenging complexities of the medical profession. The youth leadership program on medicine exposes students to the techniques of doctors and nurses during hands-on clinical rounds.

Clinical Simulation Training programs developed at SiTEL, a simulation and training center in Washington, DC, metropolitan region (USA) which was the study's main site, aim at creating new immersive learning environment for students at different levels of professional development. Learning experience includes what it is like to use the latest virtual reality simulators that assist surgeons to perform minimally invasive surgeries, or "delivery" of a newborn baby using a high-fidelity birthing simulator, or leading a resuscitation team while experiencing how to save a "patient" in cardiac arrest. Doctor for A Day Simulation Program (DOC) was developed for the purposes of vocational, medical training for students, thus providing them with experience of what it is like to be trained in a high-tech simulation training environment. This training course allows a learner to capture a brief glimpse into the current and future education programs for healthcare providers. Sisters

Kristen and Lauren Johnson, aged 15 and 18 respectively, were the first recipients to participate in the Doctor for A Day Simulation Program in June of 2010. Both girls expressed an interest in pursuing a healthcare career. The teenagers said their experience at SiTEL reinforced their interest in becoming healthcare professionals (Sanfuentes 2010).

The presented study was part of the Doctor for a Day Simulation Program (DOC) focusing on exploring reciprocity between learner's characteristics and new immersive experiences provided by MedSims developed at SiTEL.

13.3 Case Study: Research Design, Methods, and Procedures

The field study was based on cross-sectional design focusing on exploring the reciprocity between learners' functional skills, attitudes toward medical simulations, professional intentions, and learning experiences provided during learning-on-demand event. A homogeneous group of 510 students balanced by gender (55% female and 45% male) with the age range from 14 to 18 years, who were rising sophomores through seniors in high school and attended a summer school at the National Student Leadership Conference (NSLC) in Washington, DC, participated in A Doctor for A Day Simulation Program at SiTEL.

The study inclusion criteria were as follows: students must be attending 9th, 10th, 11th, or 12th grade and maintaining at least a "B" average at the time of enrollment as defined by the NSLC guidelines. SiTEL of MedStar Health, chosen as the study setting, has four simulation centers in the US District of Columbia metropolitan region, providing clinical simulation-based training courses for all the disciplines in healthcare. The centers had 14,467 participants in the year 2010. SYNERGY, a simulation education research program, developed both by SiTEL and MedStar Health Research Institute, focuses its efforts on four domains including psychomotor skills, clinical reasoning, communication, and team training.

13.3.1 Research Design, Methods, and Procedures

Five hundred and ten students spent 4 h total at the SiTEL centers. Each student enjoyed 45 min in each of four out of five offered skills stations (see below for more details), with 30 min used for registration and evaluation via express assessment, *Learning Experiences with Technology Scale (LETS)*. *DOC* event was led by simulation technologists and operation managers of SiTELs simulation centers. Each station was staffed with a proctor with a student to proctor ratio of approx. 12:1. The proctor provided the overall goal of the station, performed a demonstration, and mentored the students experience each.

Educational medical simulations employed by the skills stations included the following:

Basic surgical skills: Students learned basic knot tying and suturing techniques practicing their skills on a variety of task trainers.

Endoscopic surgery: Students used simulation equipment to gain exposure for laparoscopic surgical skills employing simulation equipment that is used to train healthcare professionals in laparoscopic surgery. MedSim application utilized the latest in virtual reality simulators and task trainers for this station.

XBOX for medicine: Students participated in SiTEL's first medical game using the XBOX platform to complete modules on anatomy and physiology and navigate through a simulated bronchoscopy procedure.

High-fidelity SimExperience: Using a high-fidelity patient simulator to recreate real medical scenarios, students assisted with delivering a baby during a normal vaginal delivery scenario and/or assisted in performing lifesaving maneuvers during a cardiac arrest scenario.

Introduction to basic life support: Students were provided with an overview of the essential skills and knowledge required to become certified in basic life support. They observed and practiced what it feels like to perform chest compressions, assess unresponsiveness, and perform artificial ventilation support on a simulated patient.

Learning Experiences with Technology Scale (LETS) was used for self-assessment by all students. *LETS* is a 13-item questionnaire with each item rated on a 5-point Likert scale from totally disagree (0) to totally agree (5). The *LETS* prototype was developed and tested during robotic psychology and robotherapy study focusing on quantifying person–robot interactions along with three main domains: technology skills, attitudes, and communication modality (Libin and Libin 2006b). For the *DOC* event, the scale items were adjusted by the educational instructor and study researchers to reflect medical focus of educational simulations. Three subscales were developed. Subscale LETS_skills utilized three items assessing the level of functional skills as they relate to video gaming and digital technology (sample item: *I play video games on a daily basis*). Subscale LETS_attitudes utilized three items measuring students' attitudes toward the usefulness of MedSims in professional healthcare education (sample item: *The use of simulation provided a greater understanding of medical procedures*). Subscale LETS_intentions employed three items to measure students' intention to pursue a healthcare career (sample item: *I am currently interested in pursuing a career as a healthcare professional*). Each subscale measured responses using summative scores ranging from 0 to 15.

A single 5-point item on the *LETS* was used to assess the participant's previous exposure to MedSims through the home school course work (item: *My school includes the use of medical simulation for my course work*). Two items related to specific experiences with XBOX simulation are not included in the presented paper and were collected for the purposes to inform the development team on the ongoing progress in utilizing XBOX application in training. One item was used to control for possible false responses and was also excluded from the presented analysis.

Each student performed self-assessment via *LETS* after program completion using electronic interface under proctor's supervision. The data were stored electronically via LMS online interface (in-house developed online Learning Management Software), and de-identified data matrix was extracted in MySQL format.

13.3.2 Analysis

MySQL data were converted to a data file readable by the IBM SPSS 18.0 (Statistical Package for Social Sciences) statistical software for further analysis. Phase I of analysis included descriptive univariate and bivariate statistics using frequency distributions, means, and standard deviations for the study variables based on the item-by-item analysis and LETS subscales summative scores, measuring students' intentions, attitudes, and level of skills. During phase II, a group analysis based on univariate model of analysis was conducted using main outcome variables and covariates to compare continuous data. In phase III, an exploratory principal component factor analysis of nine variables describing three studied domains (skills, attitudes, and intentions) was conducted employing a Varimax method of rotation with Kaiser normalization using IBM SPSS 18.0 and focusing on analyzing the relationships (codependent reciprocity) between three individual domains: skills, attitudes, and intentions. For all analysis, statistical significance was defined a priori to be at the 0.05 level.

13.4 Results and Discussion: The Anatomy of Simulation Experiences

In phase I analysis, the frequency algorithms allowed to describe the study participants as follows:

- Moderately experienced user of digital technology (45% of the sample evaluated themselves as being "poor" to "average good" experts in digital technology (Internet, cell phones, etc.) usage).
- Rather moderate video gamers with only 18% playing games on a daily basis and another 16% having advanced video-gaming skills.
- With positive attitudes toward usefulness of MedSims in medical professional education with 73% providing the highest score for the item "*The use of simulation provided an engaging learning experience*" and another 22% of the participants providing next to the highest score for the same item.
- Almost 92% of learners thought that the use of medical simulations provided them with a better understanding of medical procedures used in MedSims.
- Eighty-nine percent enjoyed their immersive interactive experiences, and 77% of the students wanted more similar participation in the future.
- With regard to their past experiences, 53% of learners indicated as unsatisfactory the use of MedSims by their home school to support relevant course work.
- When evaluating their career intentions, 80% of participants thought of a healthcare field as an attractive career path because of their immediate experiences with MedSims at SiTEL, and 87% were interested in exploring more possibilities with regard to healthcare professions.

Table 13.1 Characteristics of domains' summary scores

Individual domain	Mean	Standard deviation	Scores range
*LETS*_skills	8.09	3.29	3–15
*LETS*_attitudes	13.76	1.54	7–15
*LETS*_intentions	8.72	1.33	4–10

Table 13.1 presents summary scores resulting from phase II analysis for each *LETS* subscale that were calculated with the following means and SD:

A univariate analysis based on General Linear Model aimed at studying reciprocal relationships between study main outcome variables, the summative scores for each of the individual domains measured via LETS, and the covariate variable that assessed students' past experiences with MedSims at their home school. Results demonstrated that higher sum scores on *LETS*_attitude and *LETS*_intentions domains were not impacted by the high scores on *LETS*_skills domain, when adjusted for the level of past experiences with MedSims. This finding was also confirmed using a different analytic technique. A subgroup comparison based on the independent *t*-test, with the item evaluating learners' past experiences with MedSims used as a group criteria, revealed that the subgroups differ only on the level of functional skills ($F = 15.4$, $p = 0.001$), with the lower skills associated with minimal or no past experiences with MedSims.

An exploratory principal component factor analysis, employed for phase III analysis, using the Varimax method of rotation revealed that a clustering pattern based on a two-factor solution incorporating all three studied domains (skills, attitudes, and intentions) accounted for 68.5% of the observed variance. The resulting first factor included items from two domains, attitudes and intentions, with the second factor indicating a latent dimension of functional skills (see Table 13.2).

A variable indicating past experiences with MedSims at the home school, as well as age and gender, constituted a hypothetical secondary level in our factor model and was excluded for the purposes of the presented study, so that interrelations among the experiential learning domains could be further explored. We hypothesized that identified factors are oblique or non-orthogonal in order to achieve a more interpretable structure. The oblique method of computation rotates factors so as to best represent clusters of variables without the constraint of factors' orthogonality. A resulting two-factor model, similar in its structure to the model explored while using orthogonal algorithm, represented 68.5% of the variance. The content of the factors, as well as its order identified via the first factor analysis method, was confirmed by the oblique algorithm using Promax with Kaizer Normalization Rotation (see Table 13.2). The first factor accounted for 42.8% of the total variance, with the second factor accounting for 25.7% total variance, respectively. The oblique method allowed us to explore the reciprocal relationships between identified factors demonstrating very low correlation between factors, thus representing them as rather independent dimensions of learning experience.

Training in medical and healthcare procedures prepares students to enter a wide variety of occupations and specialty areas within the field. Multi-method analysis of

Table 13.2 A two-factor structure[a] of experiential learning domains

	Factors	
Individual domain	1	2
The use of stimulation provided an engaging learning experience	**0.733**	0.82
I am confident to choose a path toward healthcare education	**0.748**	0.128
The use of stimulation provided a greater understanding of medical procedures	**0.750**	0.024
I am an experienced user of technology	0.253	**0.646**
I play video games on a daily basis	−0.040	**0.894**
I am currently interested in pursuing a career as a healthcare professional	**0.593**	−0.062
I would like to participate in more simulation activities like this	**0.729**	0.109
I have advanced video game skills	−0.029	**0.905**

Items with highest load are in bold
[a]Rotation converged in 3 iterations

the reciprocity between three main elements of experiential learning, such as functional skills, attitudes toward MedSims usefulness in educational practice, and intentions to pursue healthcare career, revealed that despite widespread assumptions that the level of functional skills is reciprocal with cognitive domain (measured via attitudes and intentions), these factors are rather independent. At the same time, our findings demonstrate that in a large group of participating students ($N=510$), the level of functional skills relevant to mastery of interactions with cutting-edge digital technology, such as MedSims, does depend on the frequency and intensity of students' exposure to medical simulations during their course work.

Results from this study have important implications for practitioners, researchers, and students alike. Vocational counselors working with students oriented toward healthcare career need to consider more than a level of testable functional skills. The focused courses that familiarize future medical professional with the nuts and bolts of their day-to-day work to be, combined with motivational profession-tailored training, could tremendously increase recruitment rates and address healthcare shortage.

13.5 Conclusion: Building Career Technology Education

Presented case study thought to provide a contribution to the area of experiential student-centered pedagogical practices by exploring reciprocal relationships between learners' characteristics (skills, attitudes, and intentions) and immersive experiences provided by highly engaging MedSims. Our findings demonstrate the following advantages of using simulation-based education for training of future healthcare professionals:

(a) An interdisciplinary approach emerging on the crossroad of exploratory educational technologies, experiential learning, and situated cognition has the potential to address vital needs in professional education through the comprehensive implementation of vocation-tailored realistic simulation.
(b) Understanding of how learner's individual characteristics impact educational outcomes allows design of student-centered approaches that take into account reciprocity between psychological domains, pedagogical designs, and students' experiences.

The study's main limitation is that it was based on convenience sample of high school students participating in a summer school, which limits the generalizability of findings. However, study findings might be also beneficial for career technology educators as they prepare curriculum for science and technology tracks. Developed conceptual and experimental framework based on experiential learning approach can serve as a basis for considerations for technology integration into the career technology educator tracks for high school students interested in pursuing medical professions.

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Chapter 14
Programming Plush Toys as an Introduction to Computer Science: The (Fraught) Question of Motivation

Yingdan Huang, Jane Meyers, Wendy DuBow, Zhen Wu, and Michael Eisenberg

14.1 Introduction

It has become something of a commonplace in undergraduate computer science programs that too few students are majoring in the discipline and, as a corollary, that too few high-school and middle-school students are developing an interest in computing. This perception was, if anything, even a bit more depressing several years ago; more recently, the number of computer science majors has begun to rebound (cf. Harsha 2010). Still, as a look at the enrollment charts will verify, the number of American undergraduates studying computer science remains far behind the numbers a decade ago, and a great deal more "rebounding" is called for. Moreover, this relative paucity of computer science students exists in the face of what ought to be a financial incentive to study the discipline: according to the US Bureau of Labor Statistics 2009 report, "computer and mathematical" occupations are projected to grow by 22.2%, and [as highlighted by Lazowska (2010)] "computer science occupations are projected to be responsible for nearly 60% of all job growth between now and 2018." Perhaps more important than the purely economic argument, computer science professors perceive the discipline as creative—it is just plain fun—and are frustrated that somehow this sense of expression and fulfillment is failing to be communicated to students. In short, neither the "carrot" of intrinsic interest nor the "stick" of economic necessity and advantage seems to be motivating sufficient numbers of students to develop an interest in computing. The under-enrollment problem is especially noteworthy among female students, who (as of a 2008–2009 survey [Zweben 2010]) constituted 11.3% of bachelor's degree graduates in the field. By contrast, even in physics—a discipline likewise perceived as having a

Y. Huang (✉) • J. Meyers • M. Eisenberg
Department of Computer Science, University of Colorado, Boulder, CO, USA
e-mail: yingdan.huang@colorado.edu; jane.meyers@colorado.edu; duck@cs.colorado.edu

W. DuBow • Z. Wu
National Center for Women & Information Technology, Boulder, CO, USA
e-mail: wendy.dubow@colorado.edu; zhen.wu@colorado.edu

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Fig. 14.1 Sample Plushbot constructions. At *top*, a computational elephant toy created by a team of middle-school students. At *bottom*, multiple views of a Plushbot cat created by one of the authors. In both cases, the plush toy incorporates a LilyPad microprocessor, among other computational elements; more detail about the Plushbot system, and various projects, will be discussed in the following sections

gender disparity—21% of bachelor's degrees are earned by women (Mulvey and Nicholson 2011).

It would not be difficult to explore these findings in still further detail, but the essential outlines of the situation are clear: computer science, as a profession, appears to be in need of a profound reconsideration of its educational mission, particularly among younger students. In our view, the central issues in this reconsideration are not exclusively cognitive in nature: that is, the problem is not primarily that students who study computer science are failing to master the subject. Rather, the fundamental problem is one of motivation, of forming an intellectual attachment to, or engagement with, computing. In order to attract younger students to computing, the subject needs to "make sense" in a personal narrative: it needs to be the type of thing that one can envision oneself doing.

To date, other research efforts have focused on attracting students to programming through the use of innovative language design (Resnick et al. 2009; Repenning et al. 2011) and web-based social networking techniques (such as sharing programs) that accompany these new designs. This chapter reports on a project undertaken with the goal of introducing younger students to programming (and to computing in general) through the medium of *tangible computing* (see for instance Xie et al. 2008; Wyeth 2008; Silver and Rosenbaum 2010): in this case, embedding computers within their own personally constructed plush toys. The project makes use of a system called *Plushbot* (Huang and Eisenberg 2011a, b), created in our lab; Plushbot is a software system that enables children (or for that matter, adults) to design and create plush toys incorporating computational elements (microprocessor, sensors, and actuators). The purpose of Plushbot, then, is to enable children to create aesthetically appealing physical artifacts that incorporate computational ideas. Plushbot was created to work with the popular LilyPad Arduino (also originally developed in our lab), a "kit" of computational pieces that can be easily sewn onto textiles and clothing using conductive thread.

The project reported here took place at a public middle school in Boulder, Colorado; we introduced the Plushbot system to a group of 60 students between the ages of 12 and 14 over a period of nearly 2 months. There were multiple objectives in this project: in part, our goal was to do formative assessment on Plushbot itself, to see what students were able to accomplish with the system, and to ascertain what difficulties they encountered with the interface. Thus, we wished to build some "lore" about the usage of the system and to see the sorts of plush toys (and programs) that young students actually construct. At the same time, we wished to see whether this sort of tangible construction could be a motivating activity—a means of introducing programming and computing in a meaningful, playful way. To this end, we administered both pre- and post-surveys of the students, inquiring about their attitudes toward computing, to see if these attitudes were affected at all by their experience with tangible computing.

The remainder of this chapter is organized as follows: in the next (second) section, we provide a brief description of the Plushbot system itself and how it can be used to create computationally enriched plush toys. The third section—the heart of the chapter—describes our study and its results. The fourth and final section of this chapter reflects on our results; here, we also discuss connections (and contrasts) with related research, expand on the issue of enhancing (and studying) motivation in general, and explore potential future directions for our own work (Fig. 14.1).

14.2 Plushbot: A System for Creating Computationally Enhanced Stuffed Toys

In this section, we briefly describe the Plushbot system itself, as well as its connection with the LilyPad Arduino kit. A more thorough description of Plushbot can be found in Huang and Eisenberg (2011b); here, we provide only a summary sketch of the application's design.

The Plushbot system consists of two web-based interfaces, both written in JavaScript and designed to work together. The Pattern Interface (shown at the top of Fig. 14.2) enables users to draw their own cloth patterns for plush toy creation or to read in existing patterns which may then be traced over using a variety of drawing tools. Additionally, the Pattern Interface includes a specific "offset tool" for sketching the paths along which pieces will eventually be sewn together, and it includes means by which pieces may be annotated and saved to a system database.

The second portion of the Plushbot system is the Playground Interface (shown at the bottom of Fig. 14.2). This interface permits the user to load a previously constructed pattern of plush toy pieces and to place representations of computational elements on those pieces: by doing so, the user can effectively plan how the physical plush toy pieces, and the accompanying physical computational elements, will be arranged. The Playground Interface also permits the users to connect computational icons with polylines or splines representing the paths to be sewn in conductive thread. Once this step is complete, the user can print the pattern and use it as a template for creating a plush toy; in addition, Plushbot can output a file in HPGL format that can be used with a laser cutter to cut felt pieces directly.

14.2.1 Hardware and Programming for Plush Toys: The LilyPad Arduino and Modkit

The Plushbot system described above is the foundational application that our students used to create their computationally enhanced plush toys. Importantly, however, the Plushbot system was built to work in concert with the LilyPad Arduino kit for creating electronic textile (or "e-textile") artifacts. The LilyPad has been described at length elsewhere (Buechley and Eisenberg 2008); essentially it comprises a collection of computational pieces designed for incorporation into textiles. Within our project, we developed a handy variant of the standard LilyPad arrangement. Typically, LilyPad pieces are sewn directly onto textiles with conductive thread, but in our project, we created a specialized set of felt pads that could be sewn onto the pieces of the plush toys. These pads were equipped with snaps; the LilyPad pieces were then sewn onto their own felt pads equipped with snaps as shown in Fig. 14.3. The idea was that the pieces in Fig. 14.3 could now be snapped on and off of the plush toys; this would enable individual computational pieces (which are moderately expensive) to be reused among different toys without undoing any stitching.

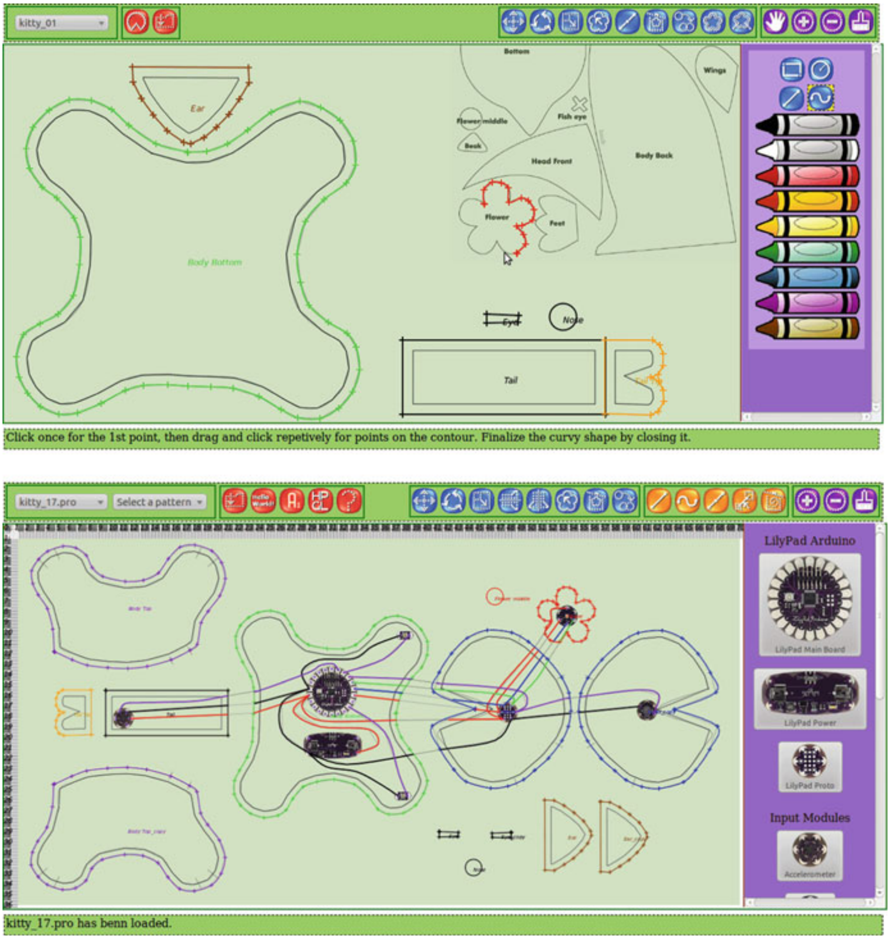

Fig. 14.2 The two interfaces for the Plushbot system, in the course of a sample project. At *top*, the Pattern Interface, with drawing tools visible at *right*; at *bottom*, the Playground Interface, in which icons for computational elements (the LilyPad components seen at *right*) may be placed and linked on the plush toy pieces to facilitate the incorporation of the physical pieces in the eventual construction

The LilyPad Arduino is typically programmed using the standard Arduino language (similar in structure to C). For this project, to render the programming task easier for students, we employed a visual programming environment, Modkit (http://www.modk.it/), designed for the Arduino. Modkit makes use of a "snap-together" programming syntax similar to that of the popular Scratch (Maloney et al. 2010) language. As in Scratch, a Modkit user employs a mouse to drag and drop "blocks" of code into a central workspace and then snaps the blocks together into larger syntactic structures to create larger programs. It should be noted, for the purposes of this brief description, that most programs written for the LilyPad Arduino (whether

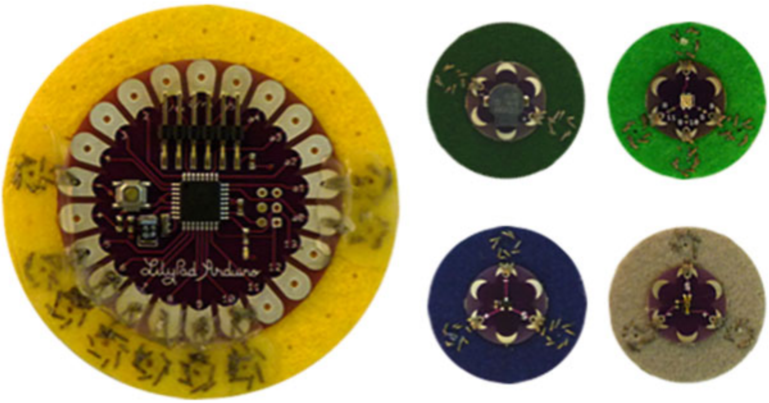

Fig. 14.3 LilyPad computational pieces specialized for plush toy creation. Each of the LilyPad kit elements (the *circular* regions shown at center of each piece) has been sewn onto a felt piece equipped with snaps. At *left*, the LilyPad microprocessor (the "main board"). At *right*, clockwise from *upper left*, a buzzer piece, RGB LED piece, light sensor, and temperature sensor

in Modkit, as in our project, or in the original Arduino language) are in fact rather simple in structure; most such programs merely monitor a sensor reading or two and respond to specific ranges of sensor values by signaling an actuator (such as an LED light or buzzer). It might thus be argued that LilyPad (and, by extension, Plushbot) is at best a very initial introduction to computer science. This is a complex subject, better left for a longer and more extended discussion; our own response to this, for the present, is simply to note that many early children's programming projects (e.g., in languages such as Scratch or Logo) are similarly brief and simple. LilyPad programs tend, indeed, to be tiny, but as an initiation into the world of programming, they are consistent with a long tradition of beginners' efforts.

14.3 Tangible Computing with Plush Toys for Middle-School Students: An Initial Project

In the spring of 2011, we conducted a pilot project using Plushbot and the LilyPad Arduino (supported by the Modkit programming environment) to introduce computing to middle-school students, aged 12–14. As noted, our goals were both to conduct formative assessment of the Plushbot system itself—to see what students would and could accomplish with the system—and to see whether this type of activity would provide motivation for further work in computer science or programming and/or enhanced confidence in programming. Approximately 60 students took part in the study, though only 46 (29 male, 17 female) completed their assent forms as well as the pre- and post-study feedback surveys. In ethnic distribution, most of the 46 students whose responses were tabulated were Caucasian (27) and 19 underrepresented minorities (nine identified as Latino, seven as Asian/Pacific Islander, two as multiracial, and one as Native American).

The study consisted of a 7.5-week workshop in creating plush toys with Plushbot. Each week there were three sessions: two of 45 min and one longer session of 1.5 h. In the initial phase of the project, students were presented with the Plushbot software and shown several completed projects; they were then taught sewing techniques and were given a practice sewing task, completing a sewn tetrahedral sack with rice inside. They were shown how to program a LilyPad LED and button in the Modkit environment and finally followed a basic Plushbot software tutorial to get a sense of the software. In the main phase of the project, students worked in small teams (of 2–4 people) to complete at least one or (if possible) two projects; we requested that each project make use of at least one button (as an input sensor) and at least one LED light (as an actuator). Each student group had access to both a shared Plushbot database (with several preprepared plush toy templates) and their own group database to save their own work. The groups also had access to a variety of physical materials: a LilyPad Arduino and several sensors, alligator clips and multimeters, conductive threads, felt sheets, scissors, and various decoration supplies (beads, googly eyes, etc.). As noted earlier, because electronic supplies were relatively scarce in comparison to the number of students, we provided "snap-on" LilyPad components so that these elements could be reused among different projects.

Before students began their work with Plushbot, they were given a pre-study questionnaire intended to measure various constructs related to computer software, programming, sewing, and electrical circuits, as well as their overall experience with these subjects. Likewise, at the conclusion of the unit, students were given a post-study questionnaire that asked about both their experiences with Plushbot and their overall reactions to the project. The pre- and post-study questionnaires included a set of questions in common in order to measure attitudinal changes (if any) after completing the Plushbot activity.

14.3.1 Results: Sample Projects and Pre-/Post-survey Comparisons

For the most part, the students in our workshop were able to complete at least one successful Plushbot project: of the 22 student groups, 19 completed at least a first project. It should be noted, however, that there was a substantial variance among the groups in the amount of time needed to complete that project: the fastest group completed its first project in only 2 weeks, while three groups failed to finish even a first project over the course of the entire workshop. Five groups went on to complete a second project; three more groups nearly completed their second project but ran out of time in the debugging process. A representative sample of working-student projects is shown in Fig. 14.4 (as well as the charming elephant toy in Fig. 14.1). In each case, the working program within the toy is of the form mentioned earlier—monitor a sensor and respond with actuator behavior; for example, the penguin figure at bottom right uses a light sensor to monitor changes in illumination and responds by "singing" songs with a speaker and flashing an LED light.

Fig. 14.4 Sample student Plushbot projects. *Upper left*: an owl figure. *Upper right*: an alien that senses temperature changes and uses an LED light to indicate the change. *Bottom left*: a lion with flashing LED eyes. *Bottom right*: a penguin that responds to light changes by singing a song and flashing an LED light

	I have never tried	I strongly agree	I agree	I'm not sure	I disagree	I strongly disagree
In general, I am interested in learning new computer software.	❑	❑	❑	❑	❑	❑
In general, learning how to use new computer software is easy for me.	❑	❑	❑	❑	❑	❑
I have learned new computer software outside of school time.	❑	❑	❑	❑	❑	❑

A similar set of three questions was asked regarding computer programming, sewing, and experimenting with electrical circuits. Both pre- and post-surveys also asked for additional comments.

Because the sample size was relatively small for the final set of surveys, no statistical tests were run on these data. Still, trends can be discerned from examining the pre/post data in two different ways—by mean responses and by percentage "agree" and "strongly agree."

Table 14.1 Mean values (strongly disagree = 1, strongly agree = 5) for pre- and post-survey responses among male and female students regarding their interest in learning new computer software, programming computers, experimenting with electrical circuits, and sewing; the perceived easiness of these subjects; and the students' engagement with these tasks outside of school

	Interest pre/post	Ease pre/post	Engagement outside school pre/post
Computer software	M: 4.07/3.93	M: 3.62/3.90	M: 3.41/3.34
	F: 3.35/2.94	F: 3.00/3.06	F: 3.00/2.76
Computer programming	M: 4.03/3.66	M: 3.03/3.24	M: 2.14/2.41
	F: 2.82/2.47	F: 2.18/2.35	F: 1.29/1.41
Electrical circuits	M: 4.07/3.69	M: 3.21/3.31	M: 2.55/2.55
	F: 3.18/2.14	F: 2.29/2.47	F: 2.24/1.53
Sewing	M: 2.97/2.90	M: 2.52/3.17	M: 2.56/2.81
	F: 4.06/3.88	F: 3.71/3.71	F: 4.13/3.63

Table 14.2 Percentage of students (male and female) who agreed or strongly agreed with pre- and post-survey statements regarding their interest in learning new computer software, programming computers, experimenting with electrical circuits, and sewing; the perceived easiness of these subjects; and the students' engagement with these tasks outside of school

	Interest pre/post	Ease pre/post	Engagement outside school pre/post
Computer software	M: 83%/69%	M: 45%/72%	M: 59%/55%
	F: 53%/35%	F: 35%/41%	F: 41%/35%
Computer programming	M: 72%/55%	M: 31%/45%	M: 21%/28%
	F: 41%/24%	F: 0%/12%	F: 0%/0%
Electrical circuits	M: 72%/55%	M: 38%/48%	M: 35%/31%
	F: 47%/24%	F: 12%/24%	F: 24%/0%
Sewing	M: 35%/38%	M: 21%/55%	M: 31%/41%
	F: 77%/77%	F: 65%/71%	F: 94%/71%

While it would be comforting to report that students' attitudes toward computers and programming uniformly improved as a result of their experience in the Plushbot workshop, the results were in fact less encouraging and definitive, and more complex. Tables 14.1 and 14.2 show responses to the key constructs being measured. The trends in responses suggest that (a) on the one hand, students were more likely to report that the various elements of the workshop (learning software, programming, electrical circuits, and sewing) were *easy* for them, yet (b) on the other hand, students were less likely to report that they were *interested* in these activities after completing the workshop. These general patterns held true for both male and female students.

Examining the percentages of students who selected "agree" and "strongly agree" to questions on the pre- and post-surveys shows increases in perceived ease of learning to use new software, programming, sewing, and experimenting with electrical circuits. For all but sewing, the percentage of boys that reported "agree" or "strongly agree" was substantially higher than the percentage of girls. The number of girls who reported that programming was easy for them increased from 0 to 2 girls pre to post, but the number of girls who reported that they programmed outside of school time remained at 0 pre to post. Responses to all other statements trended in a negative direction from pre to post evaluations.

14.4 Discussion: Next Steps

The previous section summarized both the structure of our workshop in tangible computing and several key results of our pre- and post-survey comparison. What, then, to make of these results? On the one hand, it is clear that, as measured by the surveys, our workshop did not unequivocally succeed in increasing interest in computing or programming. At the same time, most students also reported mild positive changes in their assessment of whether these subjects were easy for them, and some increased their out-of-school time with programming.

The survey results suggest, for the present, that increasing interest and engagement in computer programming remains a tall order, and that experience in tangible computing alone is hardly a panacea. At the same time, viewing the experience in retrospect, we should resist the temptation to read too much (positive or negative) into these survey results and too little into the observations and completed projects of the workshop itself. For example, it is possible that the pre-survey results indicate that in fact students originally knew very little about programming (or sewing, or circuits), in which case the post-survey results may suggest that their overall interest changed relatively little once they actually experienced these activities. In class, most students expressed pride in, and even affection for, their constructions, and the majority of post-survey comments were strongly positive. Indeed, only 4 of 20 post-workshop comments were negative; positive comments, while often brief, included (among others) contributions such as “It was cool to sew and program,” “The program was made easy to understand. The class went very smooth,” and “It was fun and it was a good experience.” These observations make the lessons of the surveys less clear-cut. Informally, we observed student ambivalence and some disappointment at the end when they realized they would be unable to keep their constructions (because of the cost of the LilyPad components); this concluding disappointment concerning their personalized projects might have had a negative influence on their post-survey attitudes, as surveys were administered after they were thus informed.[1] Finally, it is also worth noting that, qualitatively, many of the student projects exhibited creativity and significant effort (as a look at Fig. 14.4 and the elephant in Fig. 14.1 will confirm).

Clearly, then, the next step for this project is to reexamine the various elements of our workshop (Plushbot software, language environment, and structural elements

[1] In an evaluation using similar survey questions that followed weekend workshops in which the students were allowed to keep their constructions, survey results were more decidedly positive. This difference could, of course, be explained by other factors as well, including more experienced instructors and a self-selected population in the weekend workshops.

such as the availability of computational pieces and the ability to keep constructions) for their effect on motivation and interest. Likewise, we need to seek a finer-grained portrait of what, precisely, affects students' attitudes (for good or ill) toward the subject of computing and whether these factors are specific to tangible programming per se or whether they might apply to purely "screen-based" programming. Perhaps most importantly, when it comes to these novel models of computing and programming, we need to understand the arc of an individual's interests (as opposed to merely examining statistics): that is, we may find that while many students are relatively indifferent to a particular style of computing, others may be strongly affected. We will know this only through close observation and qualitative inquiries. Students' individual narratives, and the ways in which computing interest develops or fails to develop for them, should not supersede the statistical approach, but should accompany and complement it. Without such triangulation, it will prove difficult to design novel educational technologies that can help students cultivate new interests in challenging disciplines such as computing.

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Chapter 15
Serious Games and English as a Foreign Language in Primary School: A Policy Perspective

Bente Meyer, Birgitte Holm Sørensen, and Lars Birch Andreasen

15.1 Introduction

Policies can be understood as key features of modern power and governance that exist at the level of both documents, institutional practices and interactions between citizens and government officials. However, policy also has a legitimising role, for instance, in forging social identities such as the active (European) citizen, the self-managing individual or the competent child (Shore and Wright 1997; Gitz-Johansen 2004). In this sense, it can be argued that the frontiers of policy are expanding to incorporate the individual's sense of self and identity as well as the large-scale creation of social identities. The objectives of these policy processes may both be nation-building in a competitive global economy where education is understood to be a central asset and the regulation of individuals to conform to these objectives.

The role of policy in creating subjects that are digitally literate and can respond to the demands of the knowledge society is significant in the study of serious games as it must be important to understand how serious games can contribute to the strategies of school reform and innovation associated with the information and communication technology (ICT) in education policies of nation states. As mentioned above, English as a world language is an important commodity in a globalised world, as English has not only historically been a language of privilege but remains a privileged skill in global economies, and in many countries across the world, English is seen as key educational investment (Graddol 2006; Philipson 1992). Though games have often been used in basic language education for communicative activities or the training of skills (Wagner 1990; Crookall 2002; Garcia-Carbonell et al. 2001), digital games are still to some extent emergent technologies that may not be mentioned explicitly in curricula and other kinds of policy initiatives related to formal education (though there are significant exceptions to this

B. Meyer (✉) • B.H. Sørensen • L.B. Andreasen
Aalborg University, Aalborg, Denmark
e-mail: bm@learning.aau.dk; birgitte@learning.aau.dk; lba@learning.aau.dk

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rule, see, for instance, Egenfeldt-Nielsen et al. 2011). Serious games are in this sense often peripheral to educational policy, where priority is generally given to the large-scale implementation of ICTs in schools. The conceptualisation of the learner as a serious gamer may therefore to some extent collide with the idea of the competent, self-regulated learner who is a central actor in the emergent globalised information society.

In our serious games study, we have understood the integration of serious games in formal education as an aspect of digital literacy initiatives in policy, i.e. as connected to state-endorsed strategies for the implementation of ICTs in schools. This is arguably a methodological choice that could have conceptualised games differently and provided different results. However, the comparative nature of our studies in ICT policies in language education and the focus on games as a part of these policies have contributed to an understanding of how, why and where serious games are connected to the idea of the emergent information society and what this means for the market for serious games as part of teaching and learning English.

In the serious games project, we have followed specific games into local sites for teaching and learning. One of these is the game-based learning platform Mingoville.com. Mingoville.com is a learning platform for teaching children English as a foreign language and is currently marketed as “The World’s Most Comprehensive Online English Lessons for Kids – for free!” The field of serious games is widespread, and Mingoville is only one among other serious games. However, what characterises Mingoville compared to teaching materials traditionally used in many countries is that it has been developed and marketed for a global population of learners by a private company that specialises in game-based teaching and learning. This is a relatively new concept for teaching materials in Denmark, where the platform has been developed, as schools in Denmark have generally used learning material published and distributed by national publishing houses for a national audience of teachers and learners based on Danish curricula and teaching methodologies. The global address and distribution of the platform is therefore a central aspect of understanding how it works as an educational media (Hansbøl and Meyer 2011).

Mingoville is involved in different kinds of cultural flows in the sense that it addresses a global market for teaching and learning English. The global orientation of the platform is for instance presented on the home page, where it is stated that Mingoville currently has over one million users worldwide. The combination of English with a game-based concept for learning potentially makes the platform easier to distribute on a global market for education. On the other hand, restrictions in terms of schools and teachers’ attitudes to games, curriculum aims and ICT integration may determine how game-based learning is actually implemented in classrooms and other contexts for learning.

In our studies of Mingoville, we have been inspired by, e.g. anthropological approaches to explore the role of serious games in formal education, and we have done fieldwork in schools and classrooms in Denmark, Finland, Norway and the UK, where we have also interviewed teachers, pupils and school leaders. In other countries such as Singapore, Hong Kong and Vietnam, we have—due to budget and time restraints—followed policy exclusively as part of state and municipal governance through interviews with policymakers and the study of relevant documents, for instance, curriculum aims.

15.2 Methodology: Researching Policy

As mentioned above, the methodological reflections involved in our research situate serious games in global/local relationships with policymaking in the information society. In our approach to studying policy in these global/local contexts, we have been inspired by for instance Shore and Wright's anthropology of policy mentioned above (1997) and George Marcus' multi-sited ethnography (1995). The significance of Marcus' discussion with world culture theory and his challenge to the concept and methodology of single-sited ethnography is that it provides the basis for understanding field work not only as the single-sited ethnographies that inform classical studies in anthropology but as mobile ethnographies that "examine the circulation of cultural meanings, objects and identities in diffuse time-space" (1995, 96). These multi-sited ethnographies are characterised by breaking out from single-sited studies to "empirically following the thread of cultural process itself", i.e. into following moving actors and concepts in postmodern societies. Marcus identifies a number of ways of following cultural processes (actors and concepts) empirically, for instance, following the people, following the thing and following the metaphor.

Following people and things on the global market is significant to research in serious games, as researching global markets for education involves empirically following things (for instance, "commodities" such as computers, serious games) as well as people (for instance, pupils, teachers, government officials).

15.3 Researching the Policy of ICT in Education

The three countries studied below represent three examples of how policy is articulated as a complexity of connections between relevant actors in education and systems of thought that underpin objectives of implementation and innovation in schools through the dissemination of ICTs.

The three countries represent a sample of the country studies that we have carried out in the serious games project in the period 2009–2011. The country cases studied in the project have been chosen for their perceived significance for the companies and the serious games involved in the study. As mentioned above, the project has focused primarily on game-based teaching materials developed by companies and the role of these new teaching materials for learning in and outside schools. Buckingham (2007) argues that online learning is a very competitive market and that, due to high production costs, software must be even more clearly designed for a global market than books. This underlines the need for studying the ways in which commercially produced games for learning are distributed on the market and how they impact on for instance language education.

In Portugal, we have, for instance, followed Mingoville into schools as a major state-endorsed policy initiative involved distributing laptops to children in which Mingoville was a recommended learning material for teaching and learning

English. In the UK, we have focused on how an articulated policy of using serious games for innovative teaching and learning in schools may facilitate dissemination and use of the serious game Global Conflicts (http://www.globalconflicts.eu/). Other parameters for the choice of country cases have been their cultural and geographical positions in the world (for instance, Nordic countries, European countries, Asian countries), their perceived high (or low) status in educational standards (Finland) or their innovative use of ICT in education (Singapore). The three case studies chosen for this chapter represent different cultural and geographical positions in the world as well as diverging and converging approaches to the dissemination of ICT in education.

With regard to the implementation of ICT in education, Kearns (2002) argues, on the basis of a multi-country analysis of trends in policy for ICT in education, that many countries go through the same foundational phases in their policy for ICT in education. According to Kearns these are:

> *Phase one*: rolling out computers into schools and colleges with some professional development of teachers and development of online content.
> *Phase two*: mainstreaming and integrating the role of ICT into education in a more strategic way with more concern for objectives, and with linkages forged to overall education strategies (Kearns 2002, ii).

Finally, according to Kearns, a number of countries stand on the threshold of a third phase of development, which may be more radical in the way teaching and learning is conceptualised as part of the information society. An aspect of the third phase in policies for ICT in education may be an explicit articulation of innovation as part of the strategies for using ICT in schools. It may be expected that, since Kearns' study, a number of countries have moved into the third phase of ICT policy in education though it should be remembered that not all countries move at the same pace or have the same priorities. The following case studies will discuss to what extent the educational policies of the chosen nation states articulate connections between phases in the development of ICT policies for education and how this complies with their ideas of the general trends in education, including the cultural production of the educated person Levinson et al (1996). The case studies are therefore essentially narratives of the connections articulated by policymakers between large-scale trends in education and the role of serious games (including for teaching and learning English).

15.3.1 Educational Policy in Denmark

In Denmark, there has, during the past decade, been an increasing emphasis on getting computers into schools, on educating teachers and on producing digital and online learning material for specifically elementary schools. This focus on ICT in education corresponds roughly to the foundational phases described by Kearns (2002) above. A possible third phase of ICT in education policy has been initiated in the past year where more emphasis has been put on for instance the integration of digital learning material in schools.

In a former project, ICT in elementary school (IT i folkeskolen (ITIF), 2004–2007), the focus has been on distributing computers to specifically 3rd-form pupils (average age is 9 years old) and on developing digital learning materials for elementary schools. A significant element in the policy of ICT for education is a principle of government funding, which means that the government has supported a number of private companies and publishing houses financially in their work with developing digital learning material, some of which are serious games. In our project, we have, as mentioned above, followed one of these learning materials, the game-based platform for teaching and learning English, Mingoville.

In Denmark, we have interviewed two policymakers: a government official at ministerial level who has been involved in curriculum development for elementary school and an official at municipal level who has been involved in distributing and assessing a number of government-funded digital learning materials for elementary school. The relationship between these two levels of policymaking is that the municipality studied has recently initiated a large-scale free distribution of the digital learning material which has been funded by the ministry as part of the ITIF project (2004–2007). In this sense, we have followed a chain of policy that has incorporated a strategy for the distribution of ICT into elementary school, the development of digital learning material to enhance this strategy and a municipal strategy to support the use of these digital learning materials in schools in that specific local area. This chain of policy has involved the research-based development of the game-based language learning material Mingoville and has in fact contributed to the marketing of this material.

The policymaker we interviewed at ministerial level is both an active teacher and a government official. Her perspective on policy is therefore based on a double view, the view of governance and the view of practice. This double view gives us an insight into how policy is understood and how it acts at several levels of the education system.

At the ministerial level, the articulation of what policy is and what its objectives are is primarily associated with documents such as curricular and cross-curricular aims. In 1993, the Ministry of Education introduced a more standardised and aim-oriented curriculum than had previously been the case for elementary school. However, though these curriculum aims are increasingly used by the Ministry of Education in, for instance, assessments for national tests, they are still guidelines which mean that it is up to the individual municipalities, schools and teachers to interpret the aims. This is a principle of decentralisation that is pervasive in the Danish school system at the same time as policies at the ministerial level increasingly focus on standardised national testing and government initiated assessments of pupils' skills.

The Ministry of Education official focuses part of her account for the ministry's ICT in education policy on the relationship between two documents, the national curriculum aims (Fælles Mål 2009) and the aims for the integration of ICT in schools (IT og mediekompenter i folkeskolen 2010). The latter document focuses specifically on how to use ICT in schools, including Web 2.0 media, and is a development of aims for the use of ICT found in the 2009 curriculum document. She also mentions the role of the ITIF project as significant in getting ICT into schools.

In her role as a teacher, she points to a number of issues at the practical level that may work against the intentions of policy. She uses the example of teaching English, as this is part of her expertise. With regard to digital learning material, there is, for instance, the problem of schools having to buy learning material (such as Mingoville) rather than getting it for free from the ministry. The digital learning materials that have been supported financially by the government, for instance, cannot be given for free to schools because of market restrictions. This should be seen in the context of the general pressure on school budgets. Schools to a large extent, she argues, are using free material found on the Internet for teaching rather than investing in licences.

Our interview at the municipal level focuses on a policy for ICT education in a municipality situated in the eastern part of the country. The policymaker we have interviewed at the municipal level has been a teacher for many years as well as a consultant in ICT for learning. Her view is also the double view of governance and practice; however, at the time of the interview, she is deeply engaged in the municipal project of getting teachers to use the ITIF materials, among them Mingoville.

At the studied municipal level, the ICT in education policy is understood in the context of decentralisation. Decentralisation is in this case understood as a challenge as decentralisation generates the need for an initiation of policy strategies that will enable relevant ICT use to automatically spread through the relevant bodies to actors, specifically teachers and learners. In the studied municipal context, policy has, as mentioned above, focused on the dissemination of digital learning materials through a municipal investment in free user licences for schools.

15.3.2 Educational Policy in Portugal

In Portugal, there has recently been a massive effort to integrate ICT in schools, specifically in primary school. During 2009, a number of initiatives for the development of pupils' ICT competences were launched at the government level. The national effort has primarily focused on getting computers and interactive boards into schools, i.e. what corresponds to Kearn's first phase of ICT development as described above (2002). Portugal has consequently invested a lot of money in hardware. First of all, the government has had a focus on distributing computers to the pupils at a primary school level. Prior to this, secondary education schools have been equipped with computers, several hundred per school, depending on the size of the school. Training of the teachers is going to follow as a second phase of ICT integration. In relation to this, the ministry works with three levels of training. The first level concerns ICT skills, and the educational use of ICT is the second level. The third level includes teacher training especially for the teachers who are going to train other teachers, training teacher trainers.

In Portugal, we interviewed a government official at ministerial level who has been involved in the national ICT policy for primary school and a representative of the English teacher association who has been involved in developing English as foreign language in the curriculum for primary school. Locally, we have interviewed a teacher who also functions as a consultant for local government with the task of selecting and developing learning materials for the teachers and pupils in the municipality.

In the interviews, we often encountered the idea that ICT acts as a reform actor in education, i.e. that ICT has the ability to facilitate the transition of nations and learners into twenty-first-century schooling and that "things will change in very little time". This expression is employed as conclusion to the descriptions of the different efforts such as distributing computers to the youngest pupils and getting computers and interactive whiteboards into schools. The expression must be interpreted as a conviction that ICT development will proceed quickly once schools are provided with computers. Portugal's current ICT policy for primary school is characterised by an ICT strategy which mainly focuses on pupils. ICT as an artefact becomes the central actor in this strategy which is called the Magellan project—inspired by the sixteenth-century Portuguese explorer. The Magellan project is a joint venture with Microsoft to accelerate technology adoption in Portuguese schools. The aim of this project is to distribute Intel Classmate laptops to all pupils in primary school.

The purpose of providing children with laptops is, among other things, to enhance children's ICT and English language competences. Thus, the aim of the Magellan initiative is to prepare new generations for life in the information society. Laptops are specifically given to the children themselves and not to schools. The idea is that if the computers belong to the schools, the pupils cannot bring them home. By giving the computers to the children, the responsibility for the computers rests on the children and their parents. The effort must therefore be understood in relation to, e.g. the parents who will consequently have the opportunity to use the computers with their children. By making the computers the children's property, it can enable them to spend time on the computer in their spare time and thus develop their ICT and language competencies.

However, the intention is also that the computers should be used primarily in and for school. When the children receive the computers, they are installed with school-relevant learning content and school-relevant links. On each computer, there is, for instance, a desktop link to the online English language learning platform Mingoville that we are following. In this sense, Mingoville is once again involved in a chain of policy which aims to support the creation of digitally literate learners by distributing hardware and software to learners.

As mentioned above, the Magellan project is a comprehensive effort from the government for integrating the use of ICT in schools; however, through our fieldwork, we discovered that there had been several problems locally at the different schools as the school infrastructure in some cases does not fully support the implementation of ICT-based learning. For example, some schools did not have enough plugs for the laptops, which essentially meant that the daily use of the computers at the school was dependent on whether the computers were charged when the students arrived. Also, Internet connections and Wi-Fi may not be reliable in schools. This means that pupils may not be able to use their computers to go online.

In relation to the teacher level of ICT policy, the ministry has constructed an online repository of digital resources to be implemented in a so-called school portal, and all schools are being equipped with interactive whiteboards, which the teachers are obliged to use. In this sense, teachers are also implicated in the implementation of ICT for education, and in our field work, we saw that a focus on the teacher's practice with ICT (for instance, Smart Boards) was often more successful than the focus on children's use of ICT for the reasons mentioned above.

15.3.3 Educational Policy in Vietnam

Education generally has a high priority in Vietnam. In this connection, there are high expectations in Vietnam as to the contribution of ICT in education and society, and the government has developed master plans for ICT in education and for ICT and human resource development (Prime Minister 2009). As is often the case, a gap between policy and practice exists in Vietnam, and for instance, a study of five teacher education institutes in Vietnam describes in principle "a high appreciation of ICT for education, but in practice, ICT is mainly used to replace existing teaching practice" (Peeraer et al. 2009, 1).

In Vietnam, we interviewed two policymakers, a Deputy Director General of the Department of Primary Education in the Ministry of Education and Training who contributed with a general view on initiatives in the educational system, seen from a Ministerial point of view, and a researcher and Deputy Director General of the Vietnam Institute of Educational Sciences, a research institute under the ministry, who has been involved in a reform of the teaching of foreign languages that is currently being implemented in this and the following years.

In relation to establishing facilities for using ICT in the schools of Vietnam, the Vietnamese government has made an effort to establish broadband Internet connections in all schools, which should be implemented by the end of 2010, and to establish computer labs in all secondary schools. This corresponds to the initial phase of ICT implementation described by Kearns (2002) above.

Computer and Internet access is also a competitive advantage of a school. Because computers are not available in all primary schools, ICT is not fully integrated into the primary school curriculum. ICT is just mentioned as an elective subject.

Private expenditure on education in Vietnam is estimated to account for the same amount as the state expenditure on education (London 2011, 86). This is visible in that the establishment of computer labs in primary schools is partly dependent on private funding, and it corresponds with the notion of, for instance, Scanlon and Buckingham (2004) that parental investment in education is growing.

Curriculum development in Vietnam is structured as a very centralised process. Principally, there is one set of textbooks in each discipline at each grade, which is being taught in every school in the country. The curriculum framework of each discipline and grade is developed in detail by VNIES (Vietnam Institute of Educational Science) and approved by the ministry. On the basis of these curricula, the national Education Publishing House develops corresponding textbooks and teachers' guides, which are also approved by the ministry and serve as nationwide teaching materials. This means that it requires a long process of central decisions, development and approval to implement new teaching methods and develop new teaching materials.

Another challenge is related to the teaching of foreign languages, which is being reformed. Currently, students have their first foreign language, usually English, in grade 6, but in the future, the students will be introduced to a foreign language already in grade 3. This change demands a new curriculum as well as new teaching methods, partly because of the lower age of the children and partly because of a general change towards focusing on what communicative competences the students need. The aim of this policy is to change the traditional teaching method which has a weight on the teacher lecturing and the students taking notes and listening carefully.

In collaboration with a Vietnamese technology corporation, the ministry has launched a nationwide educational online game contest in maths. The game is organised as different levels of competitions where the goal is to be the best student in solving math problems. The competitions are for students individually to participate in, in their spare time, whenever it suits them. The game is not a translation of an existing game, but is developed by Vietnamese programmers and consists of 15 or more rounds of math problems that have to be solved within a specific time frame. Winners are issued with a certificate, and students with the most points are displayed at the website of the game. A similar game is developed for English teaching. The English game follows the same format as the math competition, but is developed by another Vietnamese partner, a cable television company.

15.4 Conclusion

The country cases analysed above indicate that game-based learning may have a role to play in twenty-first-century schools where there is a focus on ICT literacy and competence in English. However, our studies show that the status of games in policy for education is nevertheless relatively marginal in a number of countries where the primary focus is on creating competent learners for the twenty-first century by integrating ICT policies in schools. Large-scale ICT and education policy strategies thus dominate the field of education policy at both municipal and ministerial levels according to our studies. These large-scale initiatives evolve around the global issues of, for instance, standardisation and decentralisation trends in education, pupil and teacher roles and new public–private relationships as suggested by, for instance, Anderson-Levitt (2003). Policymakers generally characterise policy as an instrument for promoting efficiency and reform and for forging societies and individuals that will be competitive on the global market. Teaching and learning English is an aspect of the effort of nation states to respond to global challenges in education and is in various ways connected to the focus on ICT as an agent of reform.

Game-based learning is involved in the policy processes of integrating the use of technology in schools, for instance, for English language teaching and learning. However, it is not obvious from our analysis exactly how the role of game-based learning is understood in the individual countries as part of the broader educational aims suggested by policy. This may be a problem associated with methodology, as our study has hypothesised and looked for connections between game-based learning and larger national perspectives on education—specifically, those that involve digital media. A closer look at local education initiatives might, thus, have revealed a stronger practical and strategic interest in and implementation of game-based learning, for instance, for teaching and learning English.

As our studies indicate, ICTs, but not necessarily digital games, are understood by policymakers as actors that facilitate and accelerate the transition of nations and learners into the emergent information society. In this context, ICT competences—and often also language competences (in English)—become indicators of twenty-first-century basic literacy skills. Throughout the analysis, we find the idea that serious games have a significant role to play in primary education for basic skills, for instance, in language education. Games have had a role in communicative language education for decades and represent a playful approach to training skills, for instance, proficiency in the use of vocabulary. This corresponds with a recent study that indicates that specifically female teachers have a high adaptation of games in the lower grades, as games are used for basic language learning activities (Egenfeldt-Nielsen 2011).

However, the role of digital games in education is not obvious from our policy studies, and our field studies indicate that games are used in many ways, for instance, for drilling and repetition as well as for more exploratory purposes. Generally, the use of digital games is not an explicit priority in policy papers and practices.

The ways in which serious games and game-based learning are involved in broader educational trends and policies are thus both complex and inconclusive. The fact that the connections between game-based learning and local, national and global policies may be difficult to identify may depend on the fact that serious games are not a mainstream discourse in education, but also on the fact that connections are difficult to make when phenomena are not easily compared (Strathern and Edwards 2000; Marcus 1995). However, serious games and game-based learning are articulated as phenomena that have a role in the education of twenty-first-century learners, though the character and strength of these articulations vary within the national policies for education in which they are embedded.

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Chapter 16
A Serious Game Environment to Support Organisational Changes in Enterprise

Thibault Carron, Philippe Pernelle, and Jean-Charles Marty

16.1 Introduction

Nowadays, compared to traditional teaching methods, learning management systems (LMS) offer functionalities recognised as being valuable from different points of view. For instance, students can learn at their own speed. These environments also allow the teacher to evaluate specific activities in a uniform way. However, although they enable powerful features, they also receive major kinds of criticism (lack of awareness, few collaborative or regulation possibilities (Kian-Sam and Chee-Kiat 2002)). Some students tend to consider LMS as unexciting (Prensky 2000).

Concerning this particular point, agreeing with Vygotski's school of thought and activity theory (Vygotski 1934), we consider that the social dimension is crucial for the cognitive processes involved in the learning activity. Consequently, the problematic was how to enhance the social dimension in such environments. The emergence of learning games provides a possible answer to this problem and is seen as an evolution of "classical" LMS (Hijon and Carlos 2006).

As a matter of fact, during the teaching part of our work (we are both researcher and teacher), observing the emergence and success of online multiplayer games with our students at university, it was decided to experiment our own learning

T. Carron (✉)
Université de Savoie, Chambery Cedex, France
e-mail: thibault.carron@univ-savoie.fr

J.-C. Marty
Université de Savoie, Chambery Cedex, France
e-mail: Jean-Charles.Marty@univ-savoie.fr

P. Pernelle
Université de Lyon, Lyon Cedex 07, France
e-mail: philippe.pernelle@iutb.univ-lyon1.fr

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game approach, by developing a new game and using it as a support for some learning sessions. We think the way of acquiring knowledge during a learning session is similar to following an adventure in a role-playing game (RPG[1]). The combination of the two styles is called massively multiplayer online RPG (MMORPG) and offers a good potential for learning (Galarneau and Zibit 2007; Yu 2009) reformulated as massively multiplayer online learning environment (MMOLE). We have also recently decided to explore the possibility of using this playful approach to address items useful in the industry. The idea is to use the learning platform to support organisational changes and more particularly the introduction of product lifecycle management (PLM) systems in small and medium enterprises (SMEs[2]). Kadiri et al. (2009) state that the implementation of a PLM system significantly alters the organisation of the company, particularly in the context of SMEs. Resistance to (individual and collective) change naturally appears during the start-up of this type of system. We would like to make the user discover by himself/herself the gains induced by the change. The learning environment is thus used as a simulation tool, where the user first performs tedious tasks in the old-fashion way (before the introduction of change). She/he is then prepared to receive new ways of working at the end of the session. In summary, this research work has two domains of application: education (concerned roles: student and teacher) and enterprise (roles: employee and supervisor), both concern changes in enterprise.

Nevertheless, although the students or employees appreciate this approach and that game-based learning can significantly enhance learning, there is an obvious need for realistic information about users' skills, actions or behaviours especially for the teacher or the supervisor. Indeed, the latter needs to adapt his/her pedagogical session according to what is going on during the collaborative activity. But, this adaptation only becomes possible when she/he has particular information concerning the users in the environment. The global aim of this chapter is to show how a serious game may help people to admit or accept changes in their enterprise.

In this chapter, we first describe the game-based learning environment that we have developed and next focus on gathering information concerning the learners. The main point of this chapter is how to gather in the same environment information concerning general learning concepts and business concepts, for example, errors in answering specific questions or difficulties in following a new business process. Finally, in the last part, we will set out a way via an experiment to understand product lifecycle management in such learning environment. Finally, some perspectives are proposed based on the results of this work.

[1] The user plays the role of a specific character represented by an avatar who evolves during the game (skills, behaviours, appearance, etc.).

[2] Industrial partners of this research work are belonging to this type of enterprises.

Fig. 16.1 An example of a map in the learning adventure environment

Table 16.1 Classification of usage scenarios

Main category of scenario	Example
Understand basic functionalities of PLM	
Understand and accept the consequence of PLM	Reduction of errors
	Access to information
	Information security
Understand the use of PLM as a tool for collaboration	Internal collaboration
	External collaboration
Understand PLM to improve performance	Reduce the development cycle
Understand PLM to drive innovation	Knowledge reuse

16.2 Learning Adventure Environment

Learning adventure is a game-based learning management system representing a 3D environment where the learning session[3] takes place (see Fig. 16.1). A particular map (environment with lakes, mountains and hills but also buildings) is dedicated to a specific learning activity, for a specific subject (e.g. some experiments have been done for teaching operating systems, project management). Each part of the map represents the place where a given (sub-) activity can be performed.

The map topology represents the overall scenario of the learning session, that is, the sequencing between activities. There are as many regions as actual activities, and the regions are linked together through paths and non-playable character (NPC) guards, showing the attainability of an activity from others.

[3] The environment is generic and each pedagogical scenario implemented in it represents a learning session (corresponding to a "classical" course without such a numeric environment).

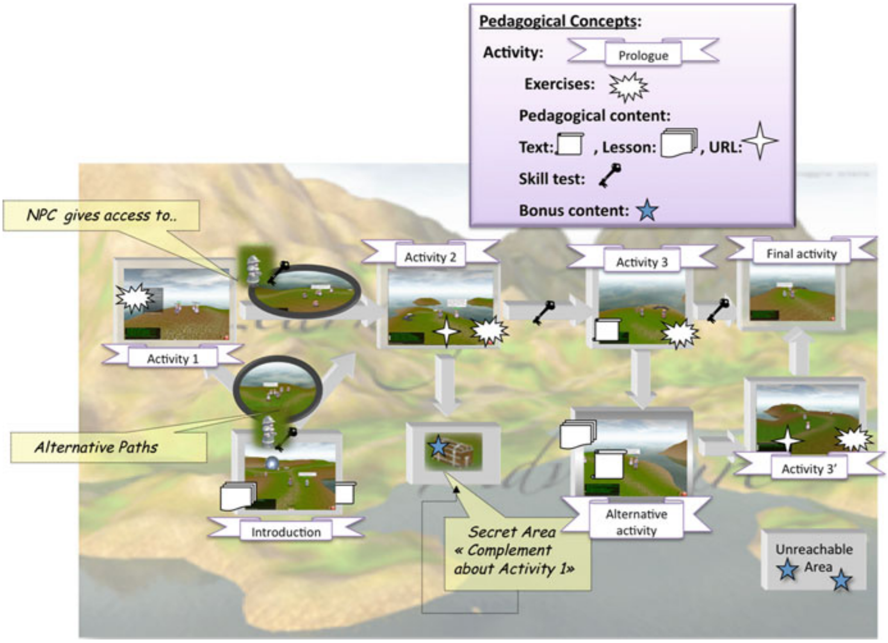

Fig. 16.2 An example of a scenario seen as a map topology

An example of a scenario seen as a map topology is presented in Fig. 16.2. Similar models that link pedagogical issues with game elements can be found with a more general point of view in Amory et al. (1999) and more precisely concerning this approach in Carron et al. (2008).

As explained before, learning adventure is based on a role-play approach (Baptista and Vaz de Carvalho 2008). Players (students or teachers), possibly represented by their own avatars, can move through the environment, performing a sequence of subactivities in order to acquire knowledge (see Fig. 16.2). Activities can be carried out in a personal or collaborative way (see Dillenbourg et al. (1996) for a list of cooperation abilities): one can access knowledge through objects available in the world, via help from the teachers or through work with other students.

Although such game environments and characteristics are well known from our students, the so-called digital natives, some reminders are always proposed at the beginning of the pedagogical session. This first playable part called the newbie park allows us to describe main functionalities and explain the use of some specific collaborative tools that are present in this game or this particular learning session. Moreover, as in many collaborative sessions, this part can be seen as a "warm-up activity" in order to get student's minds into an adequate "ready to play for learning" state.

The environment is generic in the sense that it is not dedicated to a particular teaching domain. With the help of a pedagogical engineer, the teacher adapts the environment before the session by setting prerequisites between sub-activities and by providing different resources (documents, videos, quizzes) linked to the course. Experiments have been set up for learning English as well as project management or object-oriented concepts in computer science. The collaboration takes place in LA by constituting some groups of users. The non-playable characters (NPC) will give objectives to the members of a group and give them access to collaborative tools such as white boards, file boxes or a "collaborative plan elaborator" similar to a structured discussion forum. It is then possible to construct group knowledge with specific tools. Naturally, in order to communicate with other players, a chat tool is available (bottom-left corner of the Fig. 16.1).

It is possible for the students to embark several knowledge quests in parallel. That is why it is important for them to be aware of the current active quests (right part of Fig. 16.1). In order to facilitate the navigation inside the game, the objects or NPCs to be reached in the active quests are displayed on a compass (upper-right corner of Fig. 16.1). Moreover, one can easily reach one's user model through the bag icon at the bottom-right-hand part of the screen. Nevertheless, as in commercial websites or in collaborative platforms for knowledge management, for example, the main and well-known problem of a user model is to keep it updated (Fink and Kobsa 2000). As we will see now, when needed, traces are a mean to have a summary of the knowledge already acquired (skills) and of the general behaviour in the environment.

16.3 From Traces to Collaborative Indicators

As shown in Carron et al. (2008), it is possible to obtain information from traces left by the users when using the learning game. All game-based learning environments that we have conceived have the characteristics to be fully traced (Marty and Carron 2011). Thus, after several steps (collection, selection, transformation, aggregation of different traces), we are able to provide specific indicators offering meaningful information to the teacher (see Figs. 16.3 and 16.4), especially collaborative indicators (Gendron et al. 2008). Moreover, some of these indicators may also be used to update the user model of each student and to present accurate information for the teacher.

The tracing activity is an appropriate way for reflecting in-depth details of the activity and for revealing very accurate hints for the teacher. Unfortunately, traces are objects very difficult to manage and understand. Indeed, raw traces (e.g. mouse clicks, movement on the map) are too low level to give interesting pedagogical information concerning the students (e.g. "wrong answer to question concerning second phase of the process").

In Carron et al. (2006) and France et al. (2006), we have already proposed some trace visualisations as a solution to specific observation problems. The purpose here is to be more general and offer observation features on any pedagogical tool.

As a matter of fact, we have chosen an approach that is as generic as possible and thus possibly independent from our application. The idea is to equip any application (here, the whole of the learning adventure environment) with a tracing possibility. This implies the definition of an API of required basic observations. For instance, in the learning adventure environment, actions such as "entering a new zone (workshop)" or "correctly answering a quiz" may be traced and thus collected by specific elementary probes.

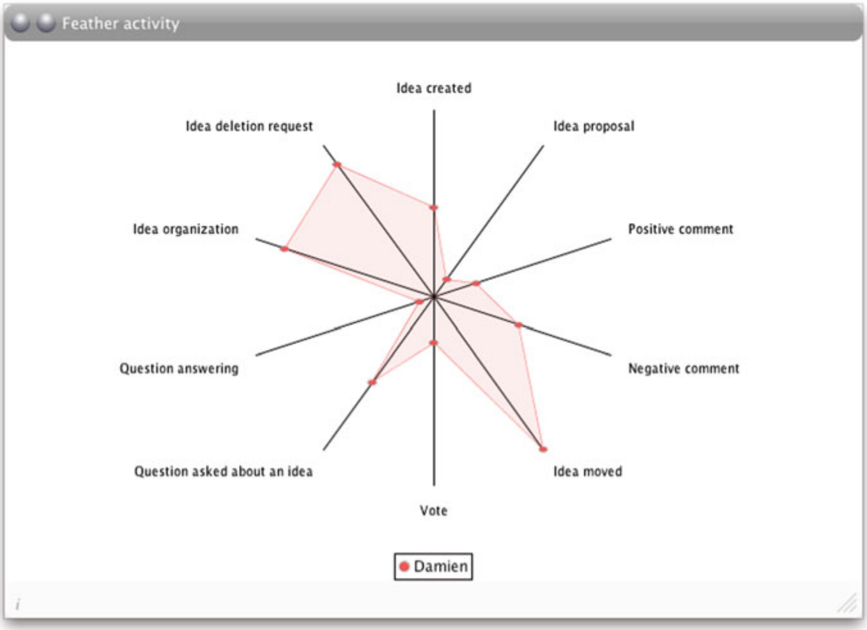

Fig. 16.3 Individual view of user's actions in the learning environment

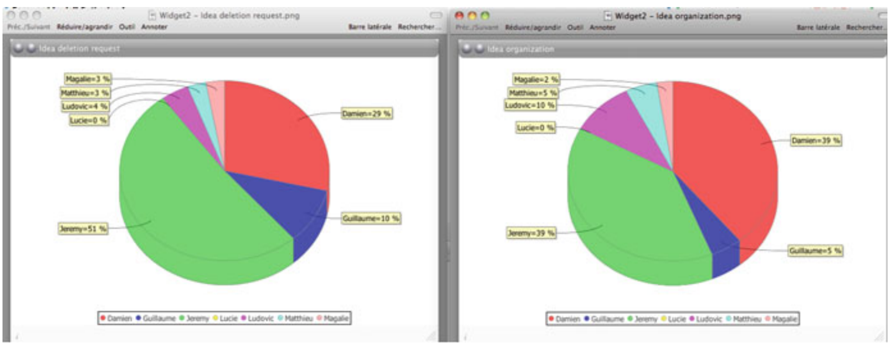

Fig. 16.4 Collective view of users' participation to a kind of action

Basically, in our environment, we defined 17 elementary probes that may be flagged at any moment by any client of our application. As seen in the table in Fig. 16.5, each probe contains some parameters and has a particular aim in order to complete a specific category of awareness, which is not often addressed (see Gutwin and Greenberg (2002) for awareness definition).

As said before, we have integrated business tools interacting with the learning adventure environment. These tools are also equipped with specific probes. For example, the actions done through the interface are collected in the game. We are

Probe Name	Parameters	Awareness category
WorkshopArriving	<UserName>, <WorkshopName>	Group-structural awareness
WorkshopLeaving	<UserName>, <WorkshopName>	Group-structural awareness
WorkshopAnswering	<UserName>, <WorkshopName>	Group-structural awareness
WorkshopAnsweringWithContent	<UserName>, <WorkshopName>, <AnswerContent>	Social awareness
WorkshopTeacherValidating	<UserName>, <WorkshopName>, <TeacherName>	Group-structural awareness
WorkshopTeacherValidatingWithContent	<UserName>, <WorkshopName>, <TeacherName>, <Comment>	Social awareness
WorkshopCorrectlyAnswering	<UserName>, <WorkshopName>, <Boolean>	Group-structural awareness
StudentConnecting	<UserName>	Informal awareness
HelpConsulting	<UserName>, <HelpName>	Group-structural awareness
Chatting	<UserName>, <ChannelName>	Group-structural awareness
ChatContentListening	<UserName>, <ChannelName>, <SentMessage>	Social awareness
GroupCreating	<GroupName>, <GroupType>, <UserName1>, <UserName2>…	Group-structural awareness
GroupSplitting	<GroupName>, <GroupSplitter>, <UserName1>, <UserName2>, …	Group-structural awareness
StudentDeconnecting	<UserName>	Informal awareness
TeacherConnecting	<TeacherName>	Informal awareness
TeacherDeconnecting	<TeacherName>	Informal awareness
TeacherHelpCalling	<UserName>, <TeacherName>	Social awareness

Fig. 16.5 List of awareness indicators

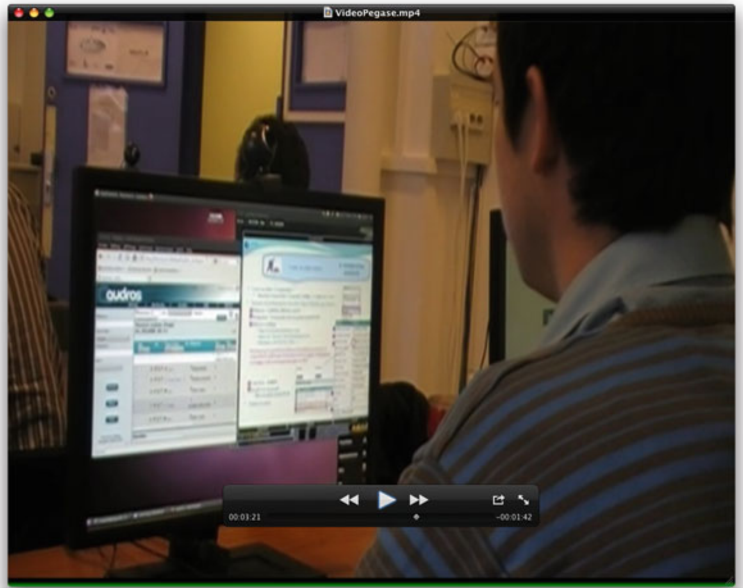

Fig. 16.6 Connection to an external business PLM tool

thus able to know who has a wrong manipulation of the business tool or the business process, provides a positive or a negative comment, asks for explanation, etc. Figure 16.6 shows a student comparing tutorial provided in the game and similar interface accessed via the game.

For a teacher, the expectations concerning the perception through the system are somewhat difficult to express. The level of what needs to be perceived may vary, as is also the case in traditional teaching: a teacher may want to observe basic facts (e.g. who starts a new activity) or more abstract facts (e.g. who regularly cooperates before answering a quiz properly). The API provides the users with elementary probes. They are thus useful for observing basic facts. However, they may not be helpful enough when the level of abstraction needed is higher. For instance, being aware only of a student consulting a help file can be not very meaningful. But if the same observation occurs just after she/he has given a wrong answer and then followed that with a success in the same activity, the teacher may be reassured as to the usefulness of the help file related to the activity. The combination of these three indicators (simple probes) allows to create a complex probe and thus to provide a higher-level explanation about the ongoing activity.

As stated previously, 17 basic indicators (simple probes) have been extracted from your learning environments (see table of Fig. 16.5), and three operators have been proposed—AND, OR, and THEN—to combine one probe with another. All these indicators may be combined with each other to define new complex probes and their representation with an administration tool. The new indicator is available in the educational platform, with the same properties as the basic probes. In particular, the new ones can be reused to create a more complex probe or indicator. Thanks to this mechanism, the set of indicators naturally increases with the help of the users, guided by the needs of observation in the platform. Starting from this point, we decided to apply this work and this environment to the problem of the product lifecycle management (PLM) in a project called PEGASE.

16.4 Scenarisation and Application to Product Lifecycle Management

The implementation of a PLM system significantly alters the organisation of the company, particularly in the context of SMEs. Resistance to change (individual and collective) appears naturally during the start-up of this type of system. According to Kadiri et al. (2009), implementation of PLM systems implies difficulties or rejection 45 times out of 100. The PEGASE project defines an environment of support for change management in industrial enterprises to help companies to effectively support their staff in adapting to the changes brought about by redesigning their information systems. The challenge of the project lies in the ability to deliver rich content to companies with an attractive environment. The success of policy change management depends on the company, its history, its industry and its approach. Approaches to change management and training often result in failure because they are not always adapted to the context. The relevance of this project is twofold: the use of video game techniques which develop the attractiveness and adjust game settings to business contexts.

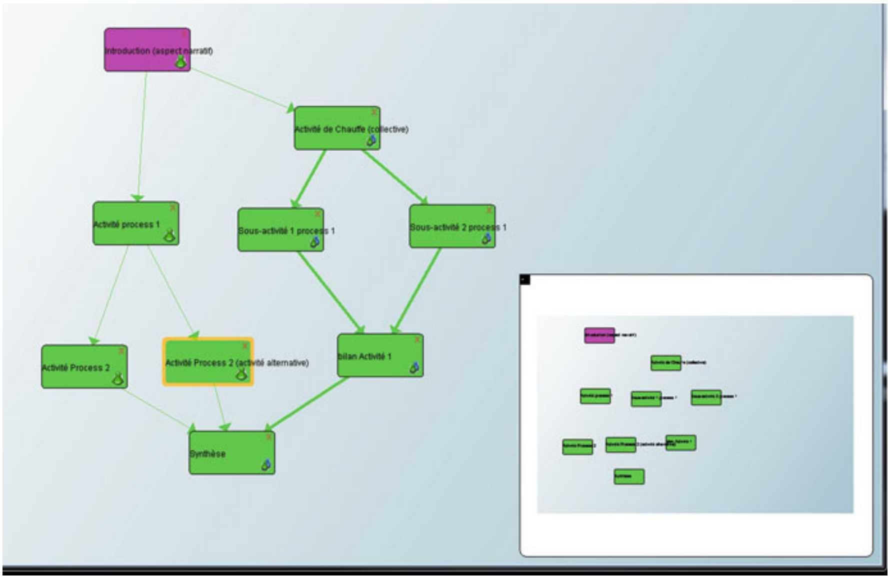

Fig. 16.7 Prototype of pedagogical scenario editor (goal approach)

16.4.1 From Pedagogical Goals to Quests in a Game Scenario

This problem called gamification is difficult to achieve. The aim is to transform a set of learning objectives prepared for a course by a teacher, for example, into a game scenario, a "quest" where each learning activity will be proposed. We have identified three scenario conception activities of different levels in gamification process and developed then three basic editors in order to help the supervisor or teacher to reach these steps.

1. The higher level concerns the pedagogical view: we proposed a goal approach allowing to express the pedagogical objectives (explain the business process, understand the benefits of a PLM system, etc.), constraints (single or collaborative activity, time, number of fails, etc.) and the scheduling of these activities (see Fig. 16.7).
2. The second level is a quest editor (see Fig. 16.8) which allows to define how the precedent activities will take place in the game (narrative aspects, non-playable characters, objects: metaphors of business concepts in the game).
3. The last part addresses the integration of all these game elements directly in the game thanks to the game editor (see Fig. 16.9).

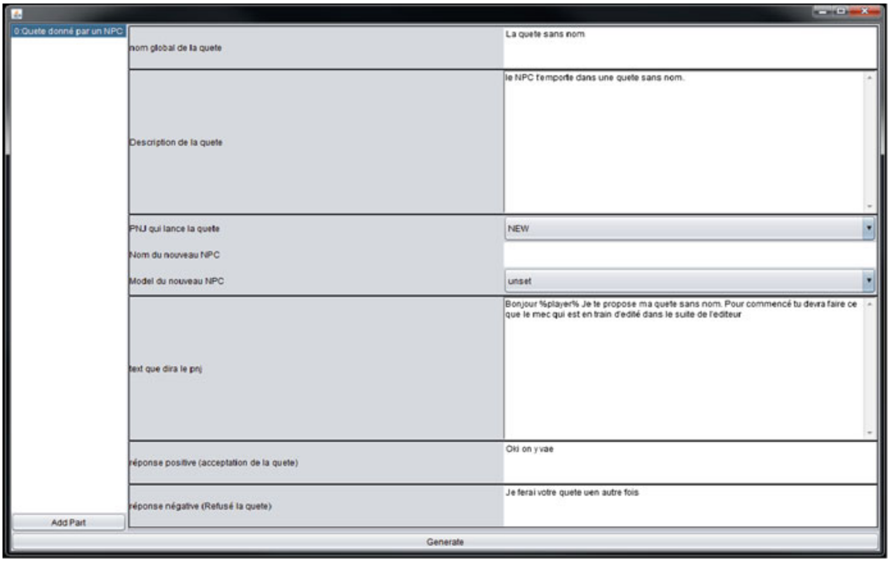

Fig. 16.8 Quest editor (metaphors and narrative aspects)

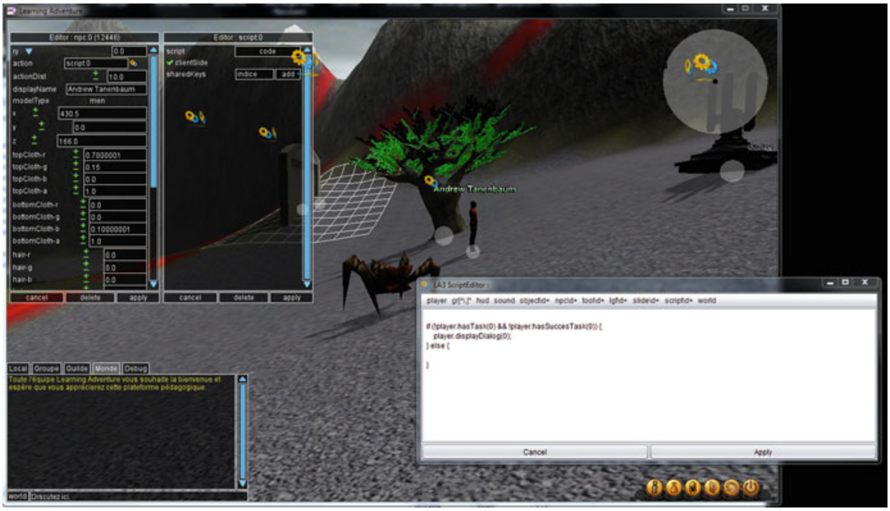

Fig. 16.9 In-game game elements editor (size, position, behaviour: scripts, etc.)

16.4.2 From Pedagogical Goals to Assessment Indicators

For this scenario, we have also defined two important constraints:

– The scripting environment should provide appropriate uses of the company's activity (automotive suppliers, toy industry, watches) and company size (multi-player scenarios, collaborative, competitive).

– An evaluation of the use and ownership of content by a user is needed.

One of the other difficulties of this project is the definition of industrial scenarios. The aim of the modelled scenarios is to understand the value of PLM. The table below shows the main features we want valued.

In the design stage, this classification enables the trainer to build his scenario from a descriptive guide. Initially, the proposed scenario is structured around a simple industrial process (purchase order) described in Fig. 16.10. Without a PLM system, this process is achieved through traditional activities where the risk of error, as well as the tedious tasks involved, should be considered.

This process is carried out initially in the PEGASE serious game without any PLM system. The figures before (see Fig. 16.11) describe some examples of actions (discussion with colleagues and watching a training presentation, collecting documents in order to complete and visualise the tasks in the process, visualisation of the order form, retrieval of information from the archives).

Once the process is carried out without a PLM system, a collective and individual balance of mistakes made by the player is displayed. A mini-training session on possible solutions to resolve their mistakes with the Audros PLM system is then proposed. The process is therefore performed in the game with a connection to the Audros PLM system.

16.5 Experiment Description

A first experiment in real conditions concerning product lifecycle management has been realised in order to validate our approach, and a demonstration has also been done at the French PLM Days in Lyon.

16.5.1 Conditions and Methodology of the Experiment

This experiment was carried out in 2011 in the University of Lyon with co-located settings (see Fig. 16.12). During the experiment, one group of 12 students with their teacher was present in the classroom equipped with 12 computers. Concerning the social presence perception (see de Kort and Ijsselsteijn (2008)), players were oriented away from each other, limiting mutual eye contact, natural reciprocation of approach or avoidance cues and mirroring. The students were between 24 and 50 years old (PLM master) and for most of all familiar with computer use. Each student accessed the virtual environment through his/her workstation and had a personal (adapted) view on the world. These students used the environment for approximately one hour and half. They were explicitly allowed to communicate through the chat tool provided with the system and were warned that they would be observed regarding the use of the system. At least, two observers were present in the classroom. The students were free to refuse this observation (the same practical work was available outside the learning environment), but everyone agreed to follow the proposed

Fig. 16.10 Screenshots of different steps of the scenario

protocol. Finally, the first part of the session deals with a fifteen-minute introduction practice called the "newbie park" in order to discover and explain step by step the basic functionalities of the game (collect bag, quest book, skill book).

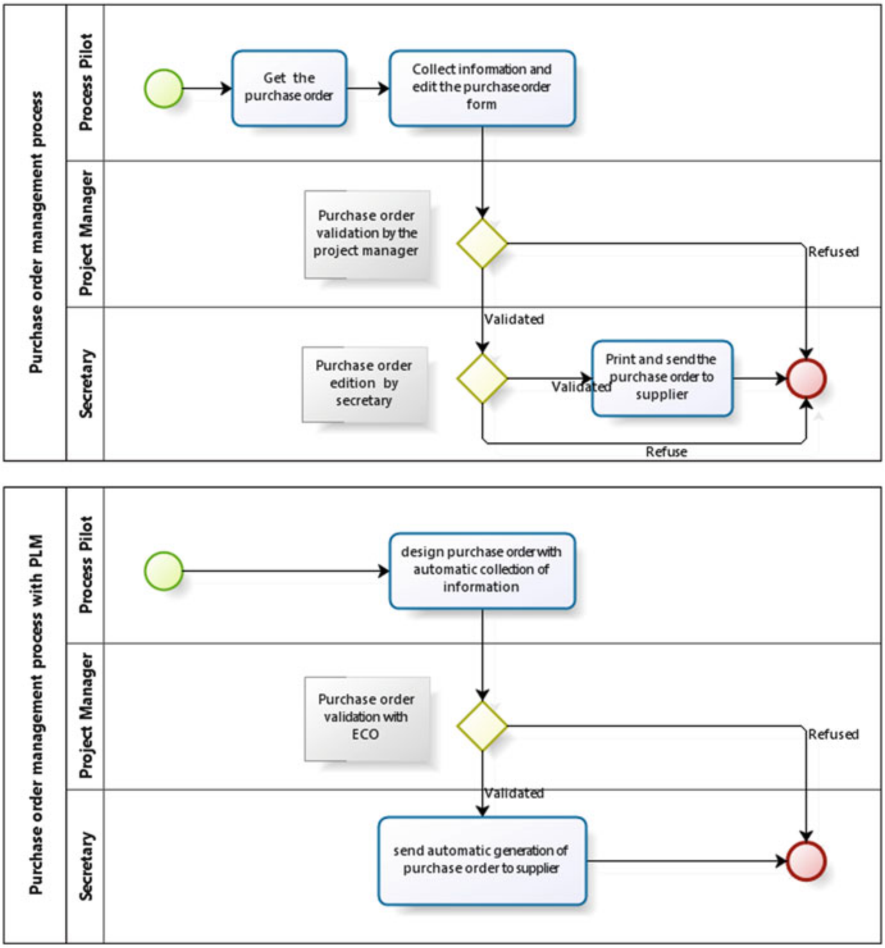

Fig. 16.11 Purchase order management process with and without PLM

16.5.2 Pedagogical Objectives

The course was dedicated to the understanding of PLM problematic. The learning content dealt with "PLM elementary concepts". As explained in the precedent part, the session was split into two parts: experimenting without (long and tedious) and with a PLM system.

The solution (final document) had to be approved by a PLM system expert who was online via the PLM business tool and was receiving each document produced. The aim of the session was to assess the knowledge and know-how of the students about the objectives of a PLM system. A story guided the knowledge quest, thanks to metaphors. Indeed, the challenge is encouraged through NPCs who propose a

Fig. 16.12 Conditions of experiments

coherent contest. Immersion is reinforced when the users' actions have a direct impact on the objects of the world. Finally, the teacher was present in the game via an avatar: it was possible to chat with him, to ask for help, for example.

16.5.3 Technical Considerations

The whole environment is coded in JAVA developed with the help of a software engineer, a level designer and students on placement (internship). The network part relies on the Red Dwarf project.[4] The whole environment is based on client–server architecture.

Thanks to traces and indicators, correct actions are automatically rewarded with the relevant skill level up. The learner's user model is consequently updated in the game, and the teacher or the PLM expert is able to take the right decisions in order to improve the learning aspects.

Moreover, SOA approach in industrial information systems aims particularly to carry out the overall integration of business components. This integration is facili-

[4] http://www.reddwarfserver.org/.

tated through various standards that allow researching and using services as an independent resource within the performing platform. In a PLM context, the need for interoperability within a company (or inter-companies) leads to the establishment of this type of architecture.

The functionality of the PLM business was defined as a web service. These services are thus accessible by the game server if there is no interaction between users (service research, service information). In the other case (interactions between players are necessary), we use the simplified HTML interfaces that are offered by all PLM systems.

16.5.4 Evaluation and Results

Concerning this experiment, two ways of evaluation were chosen:

- Quantitative, thanks to collaborative indicators elaborated with traces left by the users when collaborating
- Qualitative with live questions at the end of the session and explicit feedback from the teacher/PLM expert

At the end of the experiment, the students were asked to answer questions in order to give feedback about their feelings concerning their work session. The questions (ranking and open-ended questions) evaluated aspects relating to several parts of the learning game (pedagogical content, business concepts, affordance of the objects or tools, scenario story, immersion, collaborative activities and specifically collaborative tools, and user model evolution). The final question let the students propose improvements concerning weak and strong points of the game. For example, they found that the chat must be improved (not receiving all messages but contextualised "near-me" messages).

The initial objective concerning PLM problematic perception was reached. All students would rather be working with this environment than in a more conventional and practical way and more generally were very enthusiastic about this kind of experiment.

From the teacher's point of view, in the light of previous experiments (Marty et al. 2009; Bisognin et al. 2010), it was mandatory to have tools supporting him in the monitoring task with the help of an updated user model for each student. As explained before, several indicators or observation widgets (see Figs. 16.3 and 16.4) were therefore set up in our environments in order to meet this requirement. The results were satisfying but the set-up of such tools and experiments is extremely time-consuming for the teacher. We will only see later if all these facilities may be reused easily in other domains. Other experiments with the same environment but applied to other domain (innovation, project management) are currently planned in the context of other projects.

16.6 Conclusion

In this chapter, we have illustrated a way of integrating business tools in a collaborative session of a learning game. The aim was to help users to understand and accept the benefits of changes in enterprise: deployments of new information systems fail very often because people are reluctant to change. Thanks to information found both in the game during the pedagogical session and in the use of a professional business tool. We validated this approach with several experiments concerning the product lifecycle management to conduct the change in industry with our students carried out in the learning adventure environment. This environment is collaborative, multiplayer and fully observable, thanks to traces left during the game. These traces allow us to elaborate collaborative indicators. Moreover, thanks to the feedback collected from these environments, we are able to obtain new factual indicators of collaboration exploiting traces left by the users.

Several experiments have been successfully achieved with this PLM scenario with different types of users: PLM students or industrials using or interested by PLM for their enterprises. Nevertheless, this environment will now be aimed at proposing both specific collaborative tools and facilities to help the teacher regulate a learning session in order to be able to react quickly and to focus more on collaborative aspects. Thus, in perspective we would like to see how teamwork could be self-regulated, thanks to specific functionalities of collaborative tools. We have shown an example based on several players interacting and communicating in the same environment, but with the use of real teams and roles, we may also imagine self-regulation, team regulation or autoregulation by the use of specific rules as what can be found in artificial intelligence. Self-regulation, co-regulation and socially shared regulation are precisely described in Hadwin et al. (2010).

Naturally, some drawbacks remain: we must admit that it is very difficult for the teacher to be present in the game, help the students and regulate the session even with these specific tools. At the moment, not very well-integrated indicators are present because they are very time-consuming to develop. We currently think that we can develop some specific generic indicators dedicated to only classical fields of a domain. An interesting perspective could be to develop and propose directly within the indicators some basic regulation actions such as “play specific PLM video”, “propose new (adapted) content or new (adapted) scenario” or “enable/disable such facility/ies for this student”.

Finally, in another project called serious lab for innovation (SLI), also supported by the French Ministry for the Economy, Industry and Employment, we also applied this work to another domain: innovation in industry. Naturally, another scenario was imagined, developed and proposed for that purpose. The results regarding concepts and methodology about innovation are still under processing.

From a more general point of view, “conduct the change” is a key point both for industrials and students that will experiment such problems later. Generic serious games approach will help us to link the gap between education courses (theoretical approach, thanks to pedagogical resources left in the game) and concrete experiment in professional context, thanks to the integration of real business tool (access to interfaces via web services).

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Part V
Epilogue

Chapter 17
Measuring What Matters in a Digital Age: Technology and the Design of Assessments for Multisource Comprehension

James W. Pellegrino

17.1 Introduction

For more than a decade, assessment has constituted one of the most controversial issues in education with respect to matters of theory, design, implementation, and educational policy (see e.g., Pellegrino et al. 2001). Many of the arguments surround what we assess, how we assess, and the ways in which information derived from assessments is used to shape educational practice. As argued in various sources (e.g., Pellegrino and Quellmalz 2010; Quellmalz and Pellegrino 2009), new technologies provide opportunities to shift our assessment systems from a primary focus on summative and accountability practices to one focused instead on formative uses in which assessment information becomes an integral part of the teaching and learning process. But it is not simply a matter of using technology to shift how we assess students nor the uses to which we put the information. Most importantly, it is a matter of careful considerations of what can and should become the targets for assessment—the types of knowledge and skill that arise in a twenty-first-century digital world and that are essential for academic and personal success. It is the confluence of method, use, and content that offers the greatest chance for a dramatic shift in the productive integration of assessment into the processes of teaching and learning.

This chapter provides an overview of issues associated with research and development to effect a more productive connection between technology and the design and deployment of assessments that support learning. Three contexts serve to frame the discussion. The first context is very broad and considers the ways in which educators and researchers should be thinking about technology and its intersection with the processes of teaching, learning, and assessment in K-16+ education. To frame these issues, we briefly discuss aspects of the vision put forth in the National Educational

J.W. Pellegrino (✉)
University of Illinois,
Chicago, IL, USA
e-mail: pellegjw@uic.edu

D.G. Sampson et al. (eds.), *Ubiquitous and Mobile Learning in the Digital Age*,
DOI 10.1007/978-1-4614-3329-3_17,

Technology Plan (NETP) (U.S. Department of Education 2010). The second context is more specific and focuses on important conceptualizations affecting the design of assessments. It discusses assessment as a process of reasoning from evidence and the necessary connections to theory and research on cognition and learning. Consideration is also given to the affordances of technology for expanding the scope of what we assess and how, and ways in which the information derived from the assessment process can be then be used to support the processes of teaching and learning. The third context involves components of literacy in a digital age with a specific focus on the processes of multisource comprehension. We discuss the general issues and then illustrate how the concepts and approaches in assessment design described earlier in this chapter were used to guide the development of tasks that assess components of multisource comprehension. We conclude this chapter with some of the broader implications of this work with respect to technology and the design of assessments that can support teaching and learning in a digital age.

17.2 NETP: A Vision for Technology, Teaching, Learning, and Assessment

The US Congress has mandated the creation of a National Educational Technology Plan (NETP) on roughly a 5-year cycle. The 2010 NETP takes a very different stance than the three prior plans because it arrives at a time when access to the Internet is nearly ubiquitous, growing numbers of people carry powerful connected computing devices in their pockets, and our knowledge of how people learn, from both psychological and neuroscience perspectives, is rapidly expanding (e.g., Bransford et al. 2000; Sawyer 2006). Simultaneously, the education system faces unprecedented challenges in terms of student diversity (cognitive, developmental, socioeconomic, linguistic, etc.) and strained budgets. In this climate, the 2010 NETP differs from its predecessors by focusing on core components of the educational system rather than technology per se.

The majority of the plan addresses current perspectives on *learning*, *assessment*, and *teaching*, as well as needed directions for *future research*. Furthermore, the plan thinks broadly about education, considering learning in both formal and informal contexts, across learners' entire lifetimes. The NETP urges policy makers to focus on grand challenge problems in educational research and development. "Grand challenge problems" require bringing together a community of scientists, researchers, practitioners, and policy makers to work toward their solution. One of the four grand challenge problems highlighted in the NETP is "*Design and validate an integrated system for designing and implementing valid, reliable, and cost-effective assessments of complex aspects of 21st century expertise and competencies across academic disciplines*."

The model of twenty-first-century learning described in the NETP, and that gives rise to the aforementioned assessment grand challenge, requires new and better ways to *measure what matters*, diagnose strengths and weaknesses in the course of learning when there is still time to improve student performance, and involve multiple stakeholders in the process of designing, conducting, and using assessment. In all these activities, technology-based assessments can provide data to drive decisions on the basis of what is best for each and every student and that in aggregate will lead to continuous improvement across our entire education system. Among its recommendations to create more productive assessment systems for education, the NETP advocates for the following:

- Design, develop, and adopt assessments that give students, educators, and other stakeholders timely and actionable feedback about student learning to improve achievement and instructional practices.
- Build the capacity of educators and educational institutions to use technology to improve assessment materials and processes for both formative and summative uses.

With assessments in place that assess the full range of expertise and competencies reflected in contemporary disciplinary standards (e.g., CCSSO and NGA 2010; NRC 2012), student learning data can be collected and used to continually improve learning outcomes and productivity. For example, such data could be used to create a system of interconnected feedback for students, educators, parents, school leaders, and district administrators. For this to work, relevant data must be made available to the right people at the right time and in the right form. Educators and leaders at all levels of our education system also must be provided with support—tools and training—that can help them manage the assessment process, analyze data, and take appropriate action. These are ambitious goals, and meeting them leads to a consideration of the ways in which researchers, developers, educators, and policy makers need to think about the design of assessments and systems that can measure up to these challenges.

17.3 Assessment Design: Linkages Among Theory, Research, and Technology

17.3.1 Assessment as a Process of Evidentiary Reasoning

Educators assess students to learn about what they know and can do, but assessments do not offer a direct pipeline into a student's mind. Assessing educational outcomes is not as straightforward as measuring height or weight; the attributes to be measured are mental representations and processes that are not outwardly visible. Thus, an assessment is a tool designed to observe students' behavior and produce data that can be used to draw reasonable inferences about what students know. Deciding what to assess and how to do so is not as simple as it might appear.

The process of collecting evidence to support inferences about what students know represents a chain of reasoning from evidence about student learning that characterizes all assessments and from classroom quizzes and standardized achievement tests to computerized tutoring programs and to the conversation a student has with her teacher as they work through a math problem or discuss the meaning of a text. People reason from evidence every day about any number of decisions, small and large. When leaving the house in the morning, for example, one does not know with certainty that it is going to rain but may reasonably decide to take an umbrella on the basis of such evidence as the morning weather report and the threatening clouds in the sky.

The first question in the assessment reasoning process is “evidence about what?” Data become evidence in an analytic problem only when one has established their relevance to a conjecture being considered (Schum 1987, p. 16). Data do not provide their own meaning; their value as evidence can arise only through some interpretational framework. What a person perceives visually, for example, depends not only on the data she receives as photons of light striking her retinas but also on what she thinks she might see. In the present context, educational assessments provide data such as written essays, marks on answer sheets, presentations of projects, or students’ explanations of their problem solutions. These data become evidence only with respect to conjectures about how students acquire knowledge and skill.

In the *Knowing What Students Know* report (Pellegrino et al. 2001), the process of reasoning from evidence was portrayed as a triad of three interconnected elements: the *assessment triangle*. The vertices of the assessment triangle (see Fig. 17.1) represent the three key elements underlying any assessment: a model of student *cognition* and learning in the domain of the assessment, a set of assumptions and principles about the kinds of *observations* that will provide evidence of students’ competencies, and an *interpretation* process for making sense of the evidence in light of the assessment purpose and student understanding. These three elements may be explicit or implicit, but an assessment cannot be designed and implemented, or evaluated, without consideration of each. The three are represented as vertices of a triangle because each is connected to and dependent on the other two. A major tenet of the *Knowing What Students Know* report is that for an assessment to be effective and valid, the three elements must be in synchrony. The assessment triangle provides a useful framework for analyzing the underpinnings of current assessments to determine how well they accomplish the goals we have in mind, as well as for designing future assessments and establishing validity.

The *cognition* corner of the triangle refers to theory, data, and a set of assumptions about how students represent knowledge and develop competence in a subject matter domain (e.g., fractions, Newton’s laws, thermodynamics). In any particular assessment application, a theory of learning in the domain is needed to identify the set of knowledge and skills that is important to measure for the intended context of use, whether that be to characterize the competencies students have acquired at some point in time to make a summative judgment or to make formative judgments to guide subsequent instruction so as to maximize learning. A central premise is that the cognitive theory should represent the most scientifically credible understanding of typical ways in which learners represent knowledge and develop expertise in a domain.

Every assessment is also based on a set of assumptions and principles about the kinds of tasks or situations that will prompt students to say, do, or create something that demonstrates important knowledge and skills. The tasks to which students are

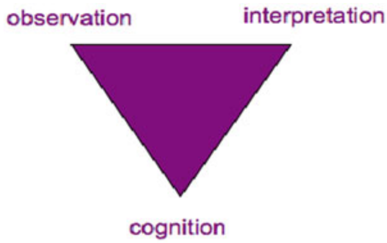

Fig. 17.1 The assessment triangle

asked to respond on an assessment are not arbitrary. They must be carefully designed to provide evidence that is linked to the cognitive model of learning and to support the kinds of inferences and decisions that will be made on the basis of the assessment results. The *observation* vertex of the assessment triangle represents a description or set of specifications for assessment tasks that will elicit illuminating responses from students. In assessment, one has the opportunity to structure some small corner of the world to make observations. The assessment designer can use this capability to maximize the value of the data collected, as seen through the lens of the underlying assumptions about how students learn in the domain.

Every assessment is also based on certain assumptions and models for interpreting the evidence collected from observations. The *interpretation* vertex of the triangle encompasses all the methods and tools used to reason from fallible observations. It expresses how the observations derived from a set of assessment tasks constitute evidence about the knowledge and skills being assessed. In the context of large-scale assessment, the interpretation method is usually a statistical model, which is a characterization or summarization of patterns one would expect to see in the data given varying levels of student competency. In the context of classroom assessment, the interpretation is often made less formally by the teacher and is usually based on an intuitive or qualitative model rather than a formal statistical one. Even informally, teachers make coordinated judgments about what aspects of students' understanding and learning are relevant, how a student has performed one or more tasks, and what the performances mean about the student's knowledge and understanding.

A crucial point is that each of the three elements of the assessment triangle not only must make sense on its own but also must connect to each of the other two elements in a meaningful way to lead to an effective assessment and sound inferences. Thus, to have an effective assessment, all three vertices of the triangle must work together in synchrony. Central to this entire process, however, are theories and data on how students learn and what students know as they develop competence for important aspects of the curriculum.

17.3.2 Assessment Development: Evidence-Centered Design

While it is especially useful to conceptualize assessment as a process of reasoning from evidence, the design of an actual assessment is a challenging endeavor that needs to be guided by theory and research about cognition, as well as practical prescriptions regarding the processes that lead to a productive and potentially valid assessment for a particular context of use. As in any design activity, scientific knowledge provides direction and constrains the set of possibilities, but it does not prescribe the exact nature of the design, nor does it preclude ingenuity to achieve a final product. Design is always a complex process that, while guided by theory and research, involves optimization under a series of multiple constraints, some of which are outside the realm of science. In the case of educational assessment, the design is influenced in important ways by variables such as its purpose (e.g., to assist learning, measure individual attainment, or evaluate a program), the context in which it will be used (classroom or large-scale), and practical constraints (e.g., resources and time).

The tendency in assessment design is to work from a somewhat "loose" description of what it is that students are supposed to know and be able to do (e.g., standards or a curriculum framework) to the development of tasks or problems for them to answer. Given the complexities of the assessment design process, it is unlikely that such a loose process can lead to generation of a quality assessment without a great deal of artistry, luck, and trial and error. As a consequence, many assessments are insufficient on a number of dimensions including representation of the cognitive constructs and content to be covered and uncertainty about the scope of the inferences that can be drawn from task performance.

Recognizing that assessment is an evidentiary reasoning process, it has proven useful to be more systematic in framing the process of assessment design as an evidence-centered design process (e.g., Mislevy and Haertel 2006; Mislevy and Riconscente 2006). Figure 17.2 suffices to capture three essential components of the overall process. As shown in the figure, the process starts by defining as precisely as possible the claims that one wants to be able to make about student knowledge and the ways in which students are supposed to know and understand some particular aspect of a content domain. Examples might include aspects of algebraic thinking, ratio and proportion, force and motion, and heat and temperature. The most critical aspect of defining the claims one wants to make for purposes of assessment is to be as precise as possible about the elements that matter and express these in the form of verbs of cognition that are much more precise and less vague than verbs such as know and understand which are high-level cognitive superordinates. Example verbs might include compare, describe, analyze, compute, elaborate, explain, predict, and justify. Guiding this process of specifying the claims is theory and research on the nature of domain-specific knowing and learning.

While the claims one wishes to make or verify are about the student, they are linked to the forms of evidence that would provide support for those claims—the warrants in support of each claim. The evidence statements associated with given sets of claims capture the features of work products or performances that would give substance to the claims. This includes which features need to be present and how they are weighted in any evidentiary scheme—that is, what matters most and what matters least or not at all. For example, if the evidence in support of a claim about a student's knowledge of the laws of motion is that the student can analyze a physical situation in terms of the forces acting on all the bodies, then the evidence might be

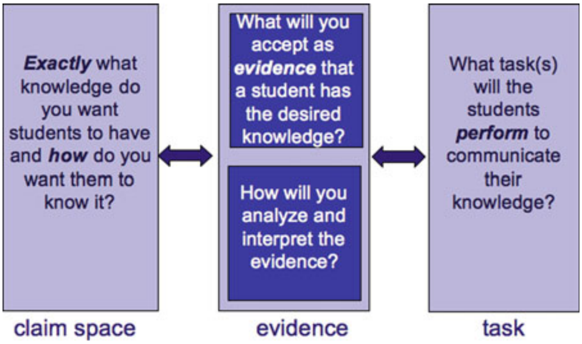

Fig. 17.2 Simplified representation of three critical components of the evidence-centered design process and their reciprocal relationships

drawing a free body diagram with all the forces labeled including their magnitudes and directions.

The precision that comes from elaborating the claims and evidence statements associated with a domain of knowledge and skill pays off when one turns to the design of tasks or situations that can provide the requisite evidence. In essence, tasks are not designed or selected until it is clear what forms of evidence are needed to support the range of claims associated with a given assessment situation. The tasks need to provide all the necessary evidence, and they should allow students to "show what they know" in a way that is as unambiguous as possible with respect to what the task performance implies about student knowledge and skill—that is, the inferences about student cognition that are permissible and sustainable from a given set of assessment tasks or items. Later in this chapter, we provide an illustration of how ECD was used to guide the development of tasks to assess components of multisource comprehension.

17.3.3 Technology and the Design of Assessments for Learning

Across the disciplines, technologies have expanded the phenomena that can be investigated, the nature of argumentation, and the use of evidence. Technologies allow representations of domains, systems, models, and data, and their manipulation, in ways that previously were not possible. Dynamic models of ecosystems or molecular structures help scientists visualize and communicate complex interactions. Models of population density permit investigations of economic and social issues. This move from static to dynamic models has changed the nature of inquiry among professionals as well as the way that academic disciplines can be taught. Correspondingly, a new generation of assessments is well on its way to transforming what, how, when, where, and why assessment occurs and its linkages to teaching and learning. Powered by the ever-increasing capabilities of technology, these twenty-first-century approaches to assessment expand the potential for tests to both probe and promote a broad spectrum of human learning, including the types of knowledge and competence advocated in various recent policy reports on education and the economy (e.g., NCEE 2007; NRC 2007).

Although early uses of technology in assessment have focused on relatively straightforward logistical efficiencies and cost reductions in large-scale testing programs (see e.g., Bennett 2008; Quellmalz and Pellegrino 2009), a new generation of innovative assessments is pushing the frontiers of measuring complex forms of learning. The computer's ability to capture student inputs permits collecting evidence of processes such as problem solving sequences and strategy use as reflected by information selected, numbers of attempts, approximation to solutions, and time allocation. Such data can be combined with statistical and measurement algorithms to extract patterns associated with varying levels of expertise (e.g., Vendlinski and Stevens 2002). Research in the learning sciences is simultaneously informing the design of innovative, dynamic, interactive assessment tasks and powerful scoring, reporting, and real-time feedback mechanisms. When coupled with technology, such knowledge has propelled various advances in adaptive testing including knowledge and skills diagnosis, the provision of immediate feedback to teachers and students accompanied by scaffolding for improvement, as well as the potential for accommodations for special populations. Technology also supports movement toward the design of more balanced sets of coherent, nested assessments that operate across levels of educational systems.

Each of the preceding constitutes a major body of theory, research, and development and deserves major treatment that is well beyond the limits of this chapter. It seems clear that the use of assessment to support the attainment of many of the NETP goals for educational improvement supported by technology will require interdisciplinary partnerships and considerable additional research and development. It will also demand major shifts in educational policies and practices regarding the designs of assessments, the models for testing, and the use of assessment data for various purposes including student, teacher, and system-level accountability.

A distinction has been made between assessments *of* the outcomes of learning, typically used for grading and accountability purposes (summative assessment), and assessments *for* learning, used to diagnose and modify the conditions of learning and instruction (formative assessment) (Stiggins 2005). The formative use of assessment has been repeatedly shown to significantly benefit student achievement (Black and Wiliam 1998; Wiliam 2007). Such effects depend on several classroom practice factors, including alignment of assessments with state or national standards, quality of the feedback provided to students, involvement of students in self-reflection and action, and teachers actually making adjustments to their instruction based on the assessment results (Black et al. 2004). Technologies are well suited to supporting many of the data collection, complex analysis, and individualized feedback and scaffolding features needed for the formative use of assessment (Brown et al. 2008). In the next section, we will provide an example of how this confluence of technology, research, and theory regarding twenty-first-century knowledge and skills, and conceptualizations of assessment and assessment design can come together in the design of multisource comprehension tasks intended to function close to the classroom and support teachers and students in the development of key literacy skills for a digital age.

17.4 Digital Literacy in the Twenty-First Century: The Design of Assessments of Multisource Comprehension

17.4.1 Perspectives on Digital Literacy

Technological developments in just the first decade of the twenty-first century have made it impossible to ignore the changing face of literacy. Both the omnipresent access to online information resources and the unprecedented rate at which these resources have grown and continue to grow have focused attention on aspects of literacy beyond those associated with reading traditional print sources: search, evaluation, and integration of information across multiple sources. Although one can argue whether these are truly "new literacies" (New London Group 1996), it is beyond argument that to be literate in the twenty-first century means being able to operate in electronic environments to address questions and solve problems that arise in academic, personal, interpersonal, and occupational contexts. Doing so means knowing how to locate relevant sources of information; evaluate sources for reliability, relevance, and quality; analyze the content of each source; and synthesize within and across multiple source (Coiro 2009; Goldman et al. 2010, 2012; Lawless et al. in press). Furthermore, Web 2.0 with its interactive capabilities increases the likelihood of collaboration and teamwork in carrying out these activities. In sum, technology-based digital environments not only make information *available* in multiple formats (e.g., audio and video as well as print) but enable answers and solutions to be produced in a range of formats. Recognition of this reality is beginning to appear in documents such as the recent Common Core Standards for English Language Arts (CCSSO and NGA 2010).

At the same time, extant data suggest that formal educational settings are providing very limited opportunities to acquire the literacy skills needed for success in the digital age (Goldman et al. 2012). A few research studies have examined upper-level high school students and college freshmen and reveal that these students use rudimentary approaches to locating, evaluating, and integrating information from multiple sources. For example, students often use imprecise key words in initial searches and have difficulty refining these for more targeted searches (Henry 2006; Recker et al. 2003). In addition, it has been demonstrated that learners' strategies for selecting from among a set of sources prioritize content overlap between the topic of the task and the information source, with limited attention devoted to evaluating the credibility or reliability of the information by examining the author, where the information was published, or the type of publication (Braasch et al. 2009; Britt and Aglinskas 2002). However, other research indicates that sensitivity to the reliability of information sources is associated with better memory and learning of the information (Kim and Millis 2006; Stadtler and Bromme 2007; Strømsø et al. 2010; Wiley et al. 2009). When it comes to analyzing and synthesizing within and across information sources, the research indicates that learners have difficulty differentiating claims from evidence and conclusions (Brem et al. 2001; Phillips and Norris 1999) and tend to approach the different information sources separately and uncritically (Foltz et al. 1996; Rouet et al. 1996). When information from multiple sources is present in a response, evidence of conceptual integration is difficult to find (Mateos and Solé 2009).

It is important to note, however, that a few recently published studies indicate that both sourcing and integration are amenable to opportunities to learn. For example, several studies demonstrate that providing learners with instructions to evaluate sources and the basis for doing so increase sensitivity to differences in reliability (Britt and Aglinskas 2002; Stadtler and Bromme 2007; Wiley et al. 2009). Other studies demonstrate that making the connections among information sources more apparent through graphical overviews has a positive effect on cross-source intertextual connections (Salmerón et al. 2009, 2010). Typically, however, the impact of such supports is found to interact with prior knowledge and epistemological orientation toward the topic as well as the type of task the learner is attempting to do (Bråten and Strømsø 2006, 2010; Gil et al. 2010; Lawless et al. 2007).

The foregoing research findings stand in marked contrast to youths' involvement with digital media, largely in out-of-school settings. Indeed, youth are often much more actively engaged with digital media in out-of-school contexts than in in-school contexts (Lenhart et al. 2001; Perez 2009). The ethnographic studies of digital youth conducted over a 3-year period by Ito and colleagues (Ito et al. 2008) indicate the existence of a robust youth culture built around online games, social networking sites, and mobile texting and communication devices. And often they are multitasking multiple forms of input at the same time (Lenhart et al. 2001). The rapidity with which digital youth are becoming functionally literate in multimodal and multisource contexts outside of school emphasizes the gap between what happens in formal educational settings and what happens outside of school. And their mastery of these skills belies the notion that multiple source activities are too complex for middle and high school students. As the gap between in-school and out-of-school literacy practices widens, society runs the risk of creating a youth culture that increasingly views school as irrelevant to what matters outside of school and to future career paths.

It appears then that from a number of perspectives, it is important to bring a greater awareness of, and emphasis on, providing instructional support for acquiring the literacies demanded by the technology-based digital world of the twenty-first century. There are several challenges to address if this is to happen. First, educational practitioners need a better sense of the competencies, knowledge, and skills that need to be supported. Second, they need instructional techniques and materials that can be used to support them. Third, they need to know what knowledge and skills learners bring to the instructional situation and what progress they are making as a result of engaging in instruction. High-quality assessments, especially those intended to be used formatively, can address the first and third challenges and are thus critical to creating opportunities for youth to engage with twenty-first-century literacies. Formative assessments can define the knowledge and skills that are involved and specify the performances that indicate that they are present. Good formative assessments make clear what students should know and be able to do and what we would take as evidence that they know and can do it (Pellegrino et al. 2001). It makes this clear to teachers, students, parents, and other stakeholders. This brings us to a consideration of work on the assessment of a specific subset of twenty-first-century literacies: multiple source comprehension.

17.4.2 Assessment of Multiple Source Comprehension

We approached the definition of twenty-first-century skills in literacy from the standpoint of being able to use information from multiple sources of information to achieve a functional goal such as answering an inquiry question or solving some problem.[1] Too often comprehension is separate as a goal in and of itself without practical relevance or connection to the world in which we live. Perhaps that is why over half of the adult population does not read well enough to meet their own health needs. Thus, in the assessment context that was developed, students are using source texts to accomplish a specific purpose, consistent with the increased emphasis on functional reading such as that offered by OECD for the PISA assessment program (OECD 2002, 2004, 2006).

The approach to assessing multiple source comprehension relied on the formulation of assessment as a process of reasoning from evidence described earlier in Sect. 17.3.1 as well as the evidence-centered design approach described in Sect. 17.3.2. In embarking on the assessment development process, we first constrained the type of multiple source comprehension that we wanted to assess by focusing on situations in which students were using multiple sources to answer an inquiry question in history or science. Historians and scientists routinely use multiple text sources to address questions in their fields to generate new theories, data, explanations, and knowledge claims (Goldman 2004; Shanahan and Shanahan 2008; VanSledright 2002). In doing so, they evaluate the credibility of the information source, the reliability of the data, and the strength of the evidence supporting various claims. However, the importance of each of these processes and the criteria used in the evaluation process are not the same across the two disciplines (Lee and Spratley 2010; Moje and O'Brien 2001; Shanahan and Shanahan 2008). From an instructional viewpoint, both domains involve both information lookup (close-ended questions) and more extended inquiry projects (open-ended questions) (Wade and Moje 2000; Williams and Gomez 2002). Thus, developing multiple source comprehension assessment in these two disciplines allows us to specify a general set of knowledge and skills for engaging with multiple sources as well as realize the specification of the observations and the interpretation of the performance in the context of the practices of the different disciplines.

In the discussion that follows, we describe the process undertaken in the development of the assessment across the three components of ECD. One of the main pur-

[1] For a more complete description of the process of developing multiple source comprehension assessments with illustrations of the technology-based tasks and results, the reader should consult Goldman et al. (2012).

poses of the ECD approach is to prevent jumping to the design of assessment tasks that appear to have “face validity” without specifying in some detail the actual construct to be measured and the forms of evidence that specific tasks need to provide to support inferences about student competence. As illustrated below, this process of specifying a domain model for purposes of designing valid assessment tasks is both challenging and laborious.

The ECD process begins with a clear specification of the knowledge and skills that define competence in the domain of interest. This domain model becomes the basis for developing the student model. The student model is derived by creating claims regarding student performance (e.g., *the student can determine what information is relevant to the inquiry problem*) and the evidence in the student performance that is needed to support the claim. The task model defines the characteristics of the activities in which students will engage and thereby generate observations that speak to specific knowledge and skills in the student model. The interpretive model concerns how to appropriately “fit” the student model and the observations together, that is, how to use the observations as evidence for particular claims. In other words, the ECD approach provides conceptual guidance to defining what needs to be assessed, how to assess it, and how to make sense of that which is assessed.

17.4.2.1 The Domain Model

In developing the multiple source comprehension assessment, the domain model was based on extant theories, analyses, and empirical findings in library and information sciences, discourse comprehension, and literacy practices used by scientists and historians when reading in their fields. This led to the initial model illustrated in Fig. 17.3. The model consists of five components that constitute groups of knowledge and skills that are relevant to successfully using multiple sources to address inquiry questions.

Interpreting the task is the process whereby the learner comes to understand the objectives, limitations, and boundaries of the task or problem and the kind of information that is relevant to addressing it. It may involve students posing their own question or responding to questions posed by others. One issue is the degree to which learners interpret tasks and adopt task goals that reflect the intended task as conceived of by the task creator. Indeed, students, including college undergraduates, often simplify open-ended, inquiry questions by turning them into close-ended questions for which they seek a single answer, often using a single source (Wallace et al. 2000; Wiley et al. 2009). As such, correct uptake of a task is critical to any inquiry activity.

Gathering refers to processes associated with finding information that can be used to address the task. Learners might brainstorm various possible sources and how to locate them. Efficiency in this process involves a preliminary screening and may contribute to refining, altering, or substituting a new problem or question.

Sourcing and selecting refers to processes associated with determining the usefulness of sources for accomplishing the task based on initial screening of information sources that result from the gathering phase. This phase, ideally, reflects efforts to use information about a source, including its topic (indicated in title or brief summary), who wrote it, and when it was published, to determine an initial estimation of its usefulness. It also involves estimating if one has sufficient information to address the problem. Decisions about sourcing and selecting may undergo revision as deeper analysis of the sources occurs.

Analyzing, synthesizing, and integrating information within sources and across multiple sources constitute the processes of determining what information is in a source and whether it is relevant to the task. Some sources may contain information that is relevant and useful as well as information that is not. The learner has to critically evaluate the content from this perspective. Synthesis refers to determining how information from individual sources relates to the information in other sources; it involves comparison and contrast to determine whether and how information is consistent or conflicting. In the course of analysis, synthesis, and efforts to integrate information to address the task, the learner may determine that more sources are needed or some that looked relevant upon initial screening are not.

Applying information to accomplish the task requires that learners put the information together in a form that meets the constraints of the task. Learners must make decisions about whether the information adequately addresses the problem or question and how to "assemble" the information. Learners' knowledge of the norms and conventions for communicating disciplinary content plays an important role in this phase.

Finally, *evaluation* plays a central role throughout multiple source comprehension in that it occurs within each component. In addition, evaluation also serves an executive coordination function by governing movement from one component to another (see Fig. 17.3). Within each component, evaluation plays a key role in regulating the processes of that component (e.g., deciding when enough sources have been gathered or which are relevant). However, the components are also interdependent in that the kinds of sources one gathers might necessitate a reinterpretation of the task or upon evaluating the relevance of gathered sources, one might determine that more sources need to be gathered. In other words, evaluation occurs within each component and is critical to the coordination among the components. This use of evaluation is consistent with metacognitive aspects of reading multiple sources (Azevedo and Cromley 2004; Coiro and Dobler 2007).

17.4.2.2 The Student Model

Once the six overarching components in the domain model were identified, the student model was developed by unpacking each of the components in Fig. 17.3 through a process of answering the question "What is meant by each component?" in terms of the claims about the knowledge and skills that a "competent" student would possess and therefore be able to demonstrate (Mislevy et al. 2003). This is an

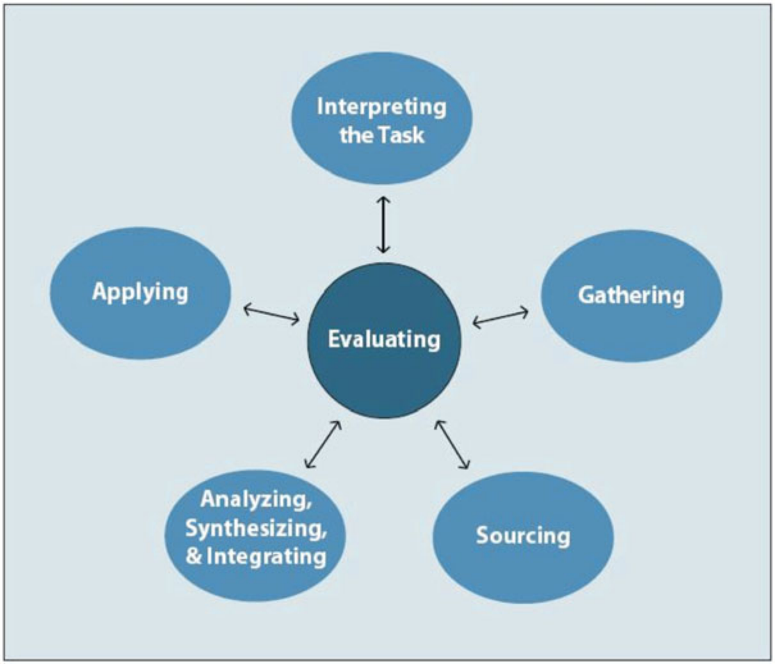

Fig. 17.3 A six-component multiple source comprehension model

iterative process that ends when the claims specify skills and knowledge that are amenable to the development of task models of observable performances that can be used to provide the critical forms of evidence relevant to specific claims. Table 17.1 shows an abridged version of this unpacking for the sourcing/selecting component. The first column lists subcomponents of sourcing/selecting, the second illustrates the nature of claim statements, and the third illustrates evidence statements and their relationship to the claims.

What the subcomponents indicate is that sourcing involves determining the relevance of a source—is the content related to answering the question or solving the problem, as well as the "reliability" of the source. "Reliability" refers to the amount and type of bias or perspective attributable to the information in a source. Various attributes of an information source provide important cues to reliability and are important in guiding how learners interpret and evaluate the information with respect to its usefulness for their task. For example, in history, knowing something about the author and the time frame of a document is informative with respect to the perspective that might be reflected in the document. That is, a British officer writing about the Boston Tea Party would be expected to have a different perspective on the event than a citizen living in Boston who was paying the tariff on tea. Journal entries or personal letters describing the event might be expected to reflect these differences in perspective, and a learner might therefore expect differences in the accounts. In science, the date and whether an article is published in a peer-reviewed journal are important to evaluating

Table 17.1 Example of the unpacking process for sourcing/selection component with accompanying claim and evidence statements

Subcomponent	Claim statement stem: The student makes use of…	Evidence statement stem: The work includes information …
Relevance	Content information during the sourcing process	About the relevance of the content for answering the inquiry question
Reliability	Attributes of the source information during the sourcing process	About the importance of source attributes
Source attributes		
Author	Author information in the sourcing process	About the credibility of the author or efforts to determine credibility of the author
Venue	Publishing location in the sourcing process	About the credibility of the publication location or efforts to determine where something was published and the credibility of it
Currency/date	Publication relative to the content of the task in the sourcing process	Indicating attention to date of publication in relation to task
Type	Differences among kinds of resources (e.g., primary vs. secondary, fiction vs. nonfiction, opinion piece/editorial vs. news story) relative to their utility for completing the task	About differences among kinds of resources and their appropriateness for the task

the quality of the data. Instrumentation available in the twenty-first century makes the collection of certain kinds of data more precise than would have been possible with the instrumentation 60 years ago. Differences in precision of the data might be very important for explaining discrepancies between data sets. The importance of an attribute in determining usefulness would be expected to fluctuate depending on the discipline and task context. A similar process was used for unpacking all of the components shown in Fig. 17.3. The results are depicted in Fig. 17.4.

17.4.2.3 The Task Model

Moving from the claim-evidence student model to actual assessments of components and subcomponents involves developing task models that make it possible to gather the kind of evidence described in the third column of Table 17.1. The task model defines the context in which the "work" is produced as well as other relevant design features of the task situation used to collect the observations. In other words, the task model describes the situations and tasks that could be used to elicit student work that can provide observations that warrant statements about specific skills or knowledge as specified in a claim. A good task model is basically a template that

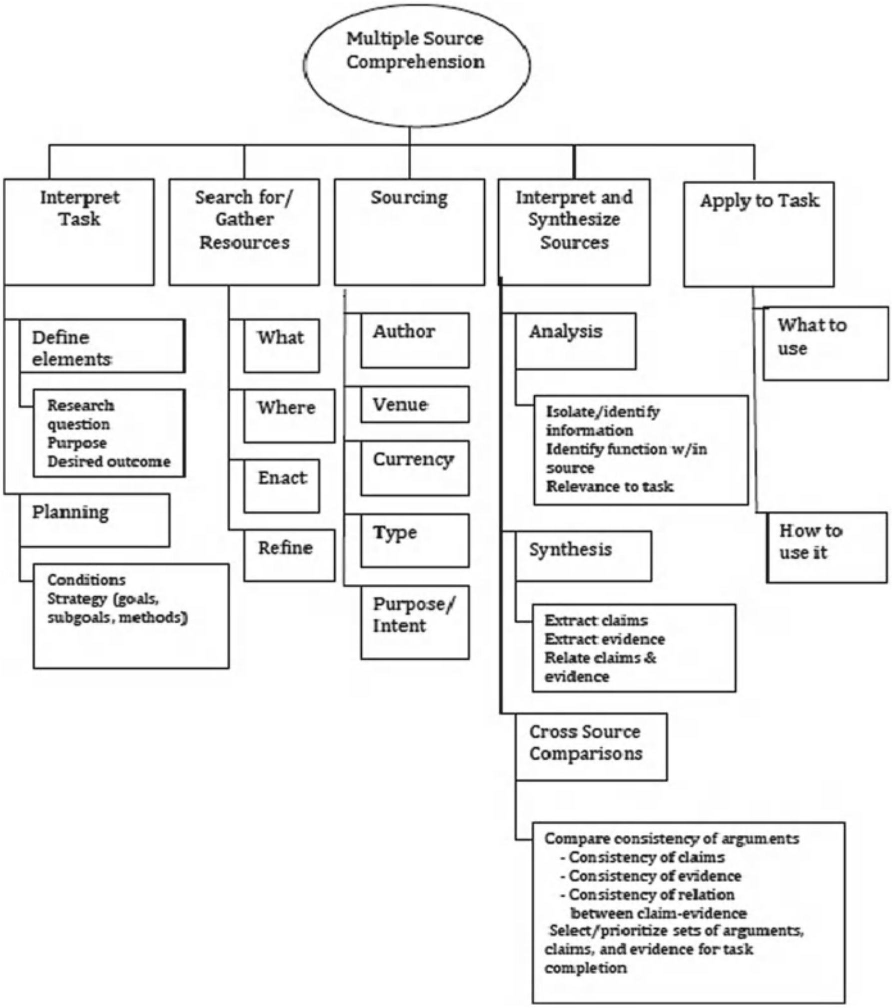

Fig. 17.4 The domain model components and student model subcomponents

isolates various attributes that can be manipulated to create multiple functionally equivalent tasks. We use the sourcing component as a context for illustrating how a task model is specified.

The task model for sourcing represents the structure and features of sourcing task situations in terms of six parameters: (1) source, (2) work product, (3) context, (4) medium, (5) scaffolding, and (6) instructions. The source parameter defines the specific attributes of the texts that need to be specified when designing a sourcing task (e.g., relevance of content, author information, venue of publication, type of publication). The source parameter also delineates some additional considerations that must be taken into account, such as the total number of sources that must be examined. The work product parameter represents the type of work product students must produce such as Likert rating, forced-choice yes/no response, and essay. The context parameter indicates the type and amount of contextualization present for a given task and includes attributes such as the presence/absence of cover story in the task. The medium parameter denotes the medium on which a task is performed (e.g., computer or paper and pencil). The scaffolding parameter characterizes the type and degrees of scaffolding provided in the task. Finally, the instruction parameter designates the specific attributes of the instructions provided to students (e.g., where they appear, how much detail is provided, and how explicit they are). In this way, the task model makes the process of assessment task design transparent because all the attributes of an assessment task situation are explicitly specified or explicitly marked as unspecified. This process, in turn, constrains the interpretation of the data the assessment task yields.

It became apparent that developing task models and actual task situations to assess each of the components shown in Figs. 17.3 and 17.4 constitutes a very large development activity. A decision was made to specifically focus task model development on two of the components: *sourcing/selection* and *analysis and synthesis and integration*. These two were prioritized because they seemed to most distinguish single source from multiple source comprehension and to constitute the core knowledge and skills important for multiple source comprehension in an electronic age (Goldman et al. 2010; Coiro and Dobler 2007).

17.4.2.4 The Interpretive Model

The interpretive model relates the observations to the student model, indicating what the observations made in an assessment task situation imply for claims about associated knowledge and skills. The interpretive model includes the rules used for scoring or evaluating responses and is shaped by the purpose of the assessment.[2] The goal was in creating a low-stakes assessment situation that would yield information that could help teachers plan multiple source comprehension instruction. As such, the interpretive model was geared toward defining what students *were* doing in the assessment task situation and what that implied about "next steps" in instruction relative to the specific subcomponent tapped by the particular assessment task. Had the goal been developing a summative assessment for purposes of ranking students, the interpretation of the observed performances would have proceeded differently. The goal of the interpretation model in the context of formative assessment is to provide teachers with information useful to instructional decision-making. The attempt was made to develop interpretive models that reflected different perfor-

[2] Our use of the term interpretive model most closely matches the evaluation component of the evidence model described by Mislevy and Haertel (2006) and is focused on the evidence rules for determining the salient features of student work to be derived from the tasks and that form the basis for claims about student competence. For our present purposes, we did not attempt to develop a formal measurement model that is considered by Mislevy and Haertel (2006) as the second major component of the evidence model.

mance profiles that had implications for instructional focus. For example, if students were using information from only one information source in responding to the inquiry question that would imply a different instructional strategy than one appropriate for students who were pulling in information from more than one source but doing so in a list format.

In the section that follows, an illustration is provided of how tasks were created and materials selected to assess one component of the domain model for multiple source comprehension—sourcing/selecting sources. This process was implemented for two history topics (immigration to Chicago and civil rights in the 1960s) and two science topics (climate change and threats to the fresh water supply). The immigration to Chicago topic is used to illustrate implementation. For a parallel discussion and illustration of the technology-based tasks, materials, and results for a second component—analysis and synthesis of information sources—the reader should see Goldman et al. (2012).

17.4.3 Illustrative Technology-Based Tasks for Assessing Sourcing/Selecting

The assessment development work was designed to provide formative assessment information to teachers of middle school students, beginning with grade 5 (approximately 11 years old) and extending to grade 8 (approximately 14 years). We developed our student model to reflect the competencies of a proficient multiple source comprehender, but our task models defined parameters within which students in this age/grade range might be able to demonstrate mastery. This meant defining the number of sources and difficulty levels of them as well as identifying content that students in this age range would be sufficiently familiar with so that prior knowledge would not severely hamper performance. The topic that is used to illustrate the assessment of sourcing/selection and analysis/synthesis is the movement of people to Chicago between 1830 and 1930, transforming it from a small town of 100 people in 1830 to a metropolis of over 3,000,000 people in 1930. The overall inquiry task for students was to address the question "Why did so many people move to Chicago between 1830 and 1930?"

In the domain model, the sourcing component operates on sources that have been returned through an initial searching and gathering process. For example, one might submit a key word or two to a Google search to gather an initial set of sources. The items among the list of sources "returned" vary in their utility for completing the task. Sourcing, as we have defined it in our domain model, refers to processes of "filtering" the items in the list of sources and selecting a subset for further, more in-depth examination. In our design, the sourcing/selection task situation defines useful sources as those that are relevant to the topic and task and that are trustworthy. The source topic along with the attribute subcomponents shown in Fig. 17.4 provides information important to determining relevance and trustworthiness. The task situation for sourcing consisted of three activities to assess students' skill at each of these: *relevance judgments*, *trustworthiness judgments*, and *usefulness ranking*. Students received a score for each of these activities. The task model specified the basic characteristics of the set of sources: The set of eight needed to reflect a range of relevance and trustworthiness but were modified versions of authentic sources found through Google searches. The information about each source was similar to what might be present in a bibliographic reference and abstract of an article: For each source, there was a title, a 25-word summary describing the content, date and publication venue, author information, and type of publication.

The set of eight sources was rated by an independent set of expert judges (members of the research team not involved in generating the sources but familiar with criteria for reliability in history). According to the expert ratings, two of the eight sources were not relevant, three were highly relevant, and three were somewhat relevant. This basic design of the source set constitutes the task model enabling the replication of the activity for additional inquiry topics.

In the Chicago immigration task, the students were introduced to the inquiry question "Why did so many people come to Chicago between 1830 and 1930?" and were told they were going to decide on the usefulness of eight sources for answering this question. They were further told that sources were useful if they were relevant to the task and trustworthy. They then completed three activities: *relevance judgments*, *trustworthiness judgments*, and *usefulness rankings*.

The first activity—*relevance judgments*—was designed to assess whether or not students could effectively discriminate relevant from irrelevant sources of information based on the content summary and title of each source. In order to help insure that we were assessing students' skills at determining whether a source was relevant and not simply their knowledge of the definition of relevance, the instructions defined relevance in the context of the assessment activity. The word relevance was purposively used to make connection with academic language and disciplinary vocabulary. All information was audio recorded so there was voice over for each screen.

Students saw the title of each of the eight sources and clicked on the source to see the summary and make the rating (see Fig. 17.5). Using a 3-point Likert-type scale (1 = highly relevant, 2 = somewhat relevant, 3 = not relevant), students judged the relevance of the content of eight sources of information in relation to the Chicago inquiry question. Once all eight sources had been rated, the student was shown the result and had an opportunity to revise any of the relevance judgments before proceeding to the second selection activity, trustworthiness judgment. Sources that a student rated as "highly relevant" or "somewhat relevant" were retained for further examination for trustworthiness. Students make no additional judgments about sources that they had deemed "not relevant."

In the second activity, the students are asked to rate the trustworthiness of any source they judged relevant by considering and rating four source attributes (author, type, publication date, and publication source). Hence, this task requires students to think about things such as the credibility of the author, the reliability of the information, and its currency. Students need to carefully attend to the source attributes in the context of the content and the inquiry question. For example, a geese-migration

Fig. 17.5 Screen shot of relevance judgment

expert may be highly credible in his/her field, but does not have any apparent expertise in historical trends in human population growth. Students make a holistic rating of trustworthiness and then provide an indication of whether each source attribute was helpful or not in deciding trustworthiness. Again, the holistic rating is 3-point Likert-type scale indicating highly trustworthy, somewhat trustworthy, and not trustworthy (see Fig. 17.6).

Only sources rated as "highly trustworthy" or "somewhat trustworthy" move forward to the usefulness ranking activity. For this activity, students are asked to rank order the sources they rated as relevant and trustworthy in terms of overall usefulness in answering the inquiry question, "Why did Chicago become a big city?" This task is accomplished by having the student assign a first place "award ribbon" to the source they thought was most useful. The students continued to award 2nd, 3rd, …*n*th place ribbons to sources until they had assigned a ribbon to each of their relevant and trustworthy sources (see Fig. 17.7).

Statistical and analytic techniques were used to convert the judgment and rating data into scores that allowed a characterization of performance on the usefulness task and how the relevance and trustworthiness judgments related to the overall usefulness decision (Lawless et al. in press). For present purposes, we simply summarize the main findings that have been replicated over several samples of students across grades 5–8.

Some students were very good at distinguishing useful from not useful sources, while others were not. For example, in a sample of 64 fifth grade students, 26 students met the criteria for good discrimination of useful from not useful sources,

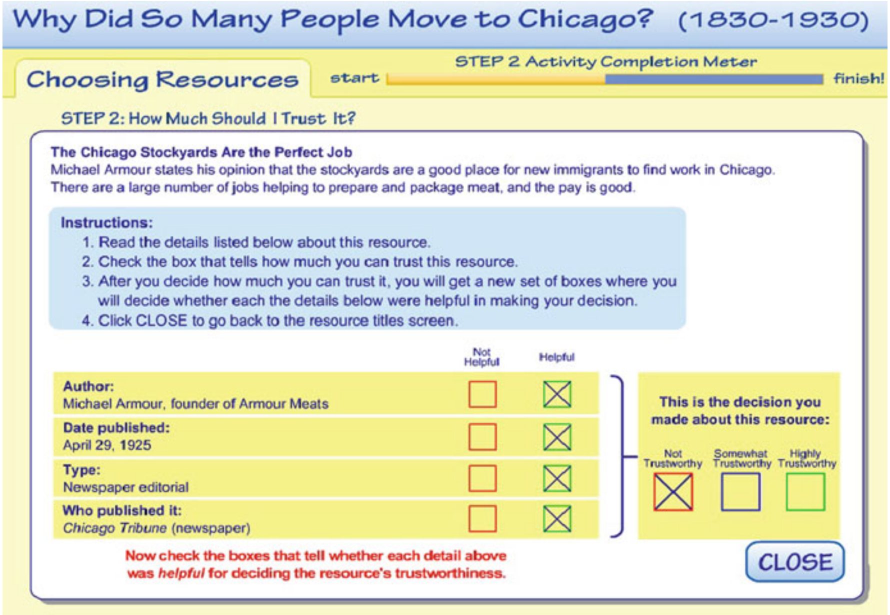

Fig. 17.6 Screen shot of trustworthiness judgment

Fig. 17.7 Screen shot of the usefulness ranking activity

while 23 met the criteria for poor discrimination of sources. Students who performed at higher levels as compared to those performing at lower levels on the usefulness ranking task also performed at higher levels on the relevance judgment task; however, performance on trustworthiness judgments did not differ significantly. Pilot trials on the trustworthiness task using an open-ended response format replicated the attribute selection data found in the forced-choice format shown in Fig. 17.6. The similar pattern across the two response formats suggests that the results are not an artifact of the response format.

One finding emerging across several samples of 5th–8th grade students who have participated in the selection task is that those students who perform at higher levels on the usefulness judgments are also more efficient in terms of making use of attribute information. That is, they pay more attention to attribute information for relevant sources than for irrelevant. In contrast, those who perform at lower levels spend time on the attributes for all sources. Thus, most students seem to know that source features such as author and date are important to consider, but students less proficient at this task are more unsure of when or why they are important to consider. Interestingly, when contrasted, the group of students who performed better on this task does not significantly differ on their performance on the district administered, standardized reading achievement test from students who performed poorly on sourcing. Thus, sourcing/selection—in particular the relevance judgment subcomponent of this task—appears to be tapping skills and knowledge not tapped by traditional assessments of reading comprehension.

The preceding examples of tasks for assessing components of the *sourcing* component of multisource comprehension is just one small portion of a much larger effort to design, implement, and evaluate technology-based assessments for the twenty-first-century "skill" of digital literacy. The conceptual and assessment development work on *sourcing* and *analysis and synthesis* was guided by the ECD process described earlier in this chapter. ECD played a key role in making more transparent precisely what performances constitute complex or deep reading comprehension, leading to limited but clearly defined constructs for sourcing, analysis, synthesis, and integration. It is in fact rather humbling to realize that the grain size at which these three subcomponents were finally specified was much more constrained than initially anticipated. This grain size resulted from the ECD process of specifying the knowledge and skills along with the kind of evidence that would indicate that such knowledge and skills were present. While measured at a more microlevel than anticipated, the assessment process allowed for identification of distinct profiles and approaches to analysis, synthesis, and integration (see Goldman et al. 2012, in press). The clarity of the construct assessed provides an excellent basis for designing instruction that begins where students are and moves them forward along a developmental trajectory. As such, the assessment development process and the resulting assessment situations and task performance examples can be educative for teachers regarding aspects of multiple source comprehension that might be appropriate foci for different groups of students. Thus, initial efforts to assess multiple source comprehension, even with the limited way in the components of the domain model were operationalized, indicate clear starting points for efforts to support students' developing complex comprehension skills.

17.5 Conclusions, Implications, and Future Directions

It is an exciting time in the field of assessment for several reasons. First, individuals have realized that there are multiple roles for assessment to play in the educational process and that one of the most valuable roles is the formative function of assisting student learning. Second, cognitive research and theory have provided us with rich models and representations of how students understand many of the key principles in the curriculum, how students develop knowledge structures, and how to analyze and understand simple and complex aspects of student performance. Third, technology makes possible more flexible, tailored presentations to students of a much wider and richer array of tasks and environments where students can learn and where they can show us what they know and how they know it. Thus, there is an interesting and powerful confluence among theory, research, technology, and practice, especially as regards the integration of curriculum, instruction, and assessment.

In numerous areas of the curriculum, information technologies are changing what is taught, when and how it is taught, and what students are expected to be able to do to demonstrate their knowledge and skill. These changes in turn are stimulating people to rethink what is assessed, how that information is obtained, and how it is fed back into the educational process in a productive and timely way. This situation creates opportunities to center curriculum, instruction, and assessment around cognitive principles. With technology, assessment can become richer, more timely, and more seamlessly interwoven with multiple aspects of curriculum and instruction. The most useful kinds of assessment for enhancing student learning emphasize knowledge integration and extended reasoning, support a process of individualized instruction, allow for student interaction, collect rich diagnostic data, and provide timely feedback. The demands and complexity of these types of assessment can be quite substantial, but technology makes them feasible. In diagnostic assessments of individuals' learning, for example, significant amounts of information must be collected, interpreted, and reported. No educator, whether a classroom teacher or other user of assessment data, could realistically be expected to handle the information flow, analysis demands, and decision-making burdens involved without technological support. Thus, technology removes some of the constraints that previously made high-quality formative assessment of complex performances difficult or impractical for a classroom teacher. Examples described earlier illustrate how technology can help infuse ongoing formative assessment into the learning process.

Clearly, we are just beginning to see how to harness technology to support the formative and summative functions of assessment. A great deal needs to be learned about the quality and efficacy of systems operating at both the large-scale level and the small-scale level. Not the least of the concerns facing us is the integration of assessment tools and practices into the educational system and the practices of teachers. But we must also take note of the fact that extremely powerful information technologies are becoming as ubiquitous in educational settings as they are in other aspects of people's daily lives. Technologies are almost certain to continue to provoke fundamental changes in learning environments at all levels of the education system. Many of the implications of technology are beyond people's speculative capacity. Little more than a decade and a half ago, for example, few could have predicted the sweeping effects of the Internet and social networking on education and other segments of society. The range of computational devices and their applications is expanding exponentially, fundamentally changing how people think about communication, collaboration, problem solving, connectivity, information systems, educational practices, and the role of technology in society.

While it is always risky to predict the future, it appears clear that advances in technology will continue to impact the world of education in powerful and provocative ways.[3] Many technology-driven advances in the design of learning environments, which include the integration of assessment with instruction, will continue to emerge and will reshape the terrain of what is both possible and desirable in education. Advances in curriculum, instruction, assessment, and technology are likely to continue to move educational practice toward more individualized and mastery-oriented approaches to learning, yet at the same time intertwine networking with resources, experts, and peers in problems requiring more complex forms of reasoning, problem solving, and collaboration. This evolution will occur across the K-16+ spectrum. To manage learning and instruction effectively, people will want and need to know considerably more about what has been mastered, at what level, by whom, and with what levels of scaffolding.

Consider the possibilities that might arise if assessment is integrated into instruction in multiple curricular areas and the resultant information about student accomplishment and understanding is collected with the aid of technology. In such a world, programs of on-demand external assessment such as state achievement tests might not be necessary. Instead, it might be possible to extract the information needed for summative and program evaluation purposes from data about student performance continuously available both in and out of the school context.

Technology could offer ways of creating, over time, a complex stream of data about how students think and reason, independently and collaboratively, while engaged in important learning activities. Information for assessment purposes could be extracted from this stream and used to serve both classroom and external assessment needs, including providing customized feedback to students for reflection about their knowledge and skills, learning strategies, and habits. To realize this vision, additional research on the problem and data representations and analysis methods best suited for different learning goals, audiences, and different assessment objectives would clearly be needed—and is certainly doable.

We can therefore imagine a future in which the audit function of assessments external to the classroom would be significantly reduced or even unnecessary because the information needed to assess students, at the levels of description appropriate for various monitoring purposes, could be mined from the data streams generated by students in and out of their classrooms. A metaphor for such a radical shift in how one "does the business of educational assessment" exists in the world of retail outlets, ranging from small businesses to supermarkets to department stores. No longer do these businesses have to close down once or twice a year to take inventory of their stock. Rather,

[3] This scenario is adapted from one originally developed in Pellegrino et al. (2001).

with the advent of automated checkouts and barcodes for all items, these enterprises have access to a continuous stream of information that can be used to monitor inventory and the flow of items. Not only can business continue without interruption, but the information obtained is far richer, enabling stores to monitor trends and aggregate the data into various kinds of summaries. Similarly, with new assessment technologies, schools would no longer have to interrupt the normal instructional process at various times during the year to administer external tests to students. Nor would they have to spend significant amounts of time preparing for specific external tests peripheral to the ongoing activities of teaching and learning.

Extensive technology-based systems that link curriculum, instruction, and assessment at the classroom level might enable a shift from today's assessment systems, which use different kinds of assessments for different purposes, to a balanced design in which the three critical features of *comprehensiveness*, *coherence*, and *continuity* would be ensured (Pellegrino et al. 2001). In such a design, assessments would provide a variety of evidence to support educational decision-making (*comprehensiveness*). The information provided at differing levels of responsibility and action would be linked back to the same underlying conceptual model of student learning (*coherence*) and would provide indications of student growth over time (*continuity*).

Clearly, technological advances will allow for the attainment of many of the goals that educators, researchers, policy makers, teachers, and parents have envisioned for assessment as a viable source of information for educational improvement. When powerful technology-based systems are implemented in classrooms, rich sources of information about intellectually significant student learning will be continuously available across wide segments of the curriculum and for individual learners over extended periods of time. This is exactly the kind of information we now lack, making it difficult to use assessment to truly support learning. The major issue is not whether this type of innovative assessment design, data collection, and information analysis is feasible in the future. Rather, the issue is how the world of education anticipates and embraces this possibility and how it will explore the resulting options for effectively using assessment information to meet the multiple purposes served by current assessments and, most important, to enhance student learning. To a very real extent, that is what the NETP vision for technology, teaching, learning, and assessment discussed at the beginning of this chapter is all about.

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