



COMMONWEALTH *of* LEARNING

PERSPECTIVES ON OPEN AND DISTANCE LEARNING

Increasing Access through Mobile Learning

Mohamed Ally and Avgoustos Tsinakos, Editors

Increasing Access through Mobile Learning

Mohamed Ally and Avgoustos Tsinakos, Editors

COMMONWEALTH *of* LEARNING

The Commonwealth of Learning (COL) is an intergovernmental organisation created by Commonwealth Heads of Government to encourage the development and sharing of open learning and distance education knowledge, resources and technologies.



Commonwealth of Learning and Athabasca University, 2014

© 2014 by the Commonwealth of Learning and Athabasca University.
PERSPECTIVES ON OPEN AND DISTANCE LEARNING: Increasing Access through Mobile Learning is made available under a Creative Commons Attribution-ShareAlike 3.0 Licence (international):

<http://creativecommons.org/licenses/by-sa/3.0>.

For the avoidance of doubt, by applying this licence the Commonwealth of Learning and Athabasca University do not waive any privileges or immunities from claims that they may be entitled to assert, nor do the Commonwealth of Learning and Athabasca University submit themselves to the jurisdiction, courts, legal processes or laws of any jurisdiction.

PERSPECTIVES ON OPEN AND DISTANCE LEARNING: Increasing Access through Mobile Learning

Mohamed Ally and Avgoustos Tsinakos, Editors

ISBN 978-1-894975-64-3

Published by:



COMMONWEALTH OF LEARNING

1055 West Hastings, Suite 1200
Vancouver, British Columbia
Canada V6E 2E9

Telephone: +1 604 775 8200

Fax: +1 604 775 8210

Web: www.col.org

Email: info@col.org



Athabasca
University

ATHABASCA UNIVERSITY

Centre for Distance Education

1 University Drive

Athabasca, Alberta

Canada T9S 3A3

Telephone: +1 800 788-9041 (ext. 6179)

(toll free in Canada & USA)

Telephone: +1 780 675-6179

(outside Canada & USA)

Web: <http://cde.athabascau.ca>

E-mail: mohamedata@athabascau.ca

With support from:



Contents

Foreword	v
Acknowledgements	vii
Contributors	ix
Introduction: Enhancing Access to Education with Mobile Learning.....	1
<i>Mohamed Ally and Avgoustos Tsinakos</i>	

PART I: Designing Mobile Learning

Chapter 1	
A Diachronic Overview of Technology Contributing to Mobile Learning: A Shift Towards Student-Centred Pedagogies	7
<i>Helen Crompton</i>	
Chapter 2	
Educational Standards for Mobile Learning and Mobile Application Development.....	17
<i>Judy Brown, Michael Hruska, Andy Johnson and Jonathan Poltrack</i>	
Chapter 3	
A Pedagogical Framework for Mobile Learning: Categorising Educational Applications of Mobile Technologies into Four Types.....	27
<i>Yeonjeong Park</i>	
Chapter 4	
Why Open Educational Resources Are Needed for Mobile Learning	49
<i>Rory McGreal</i>	
Chapter 5	
Design of Contextualised Mobile Learning Applications	61
<i>Marcus Specht</i>	
Chapter 6	
Interactive Learning Strategies for Mobile Learning	73
<i>Anthony Ralston</i>	
Chapter 7	
Mobile Learning: Location, Collaboration and Scaffolding Inquiry.....	85
<i>Eileen Scanlon</i>	

PART II: Implementing Mobile Learning

Chapter 8	
Open Formats for Mobile Learning.....	99
<i>Geoff Stead</i>	
Chapter 9	
Using BYOD, Mobile Social Media, Apps, and Sensors for Meaningful Mobile Learning	113
<i>Inge Ignatia de Waard</i>	

Chapter 10	
Supporting Mobile Access to Online Courses: The ASK Mobile SCORM Player and the ASK Mobile LD Player	125
<i>Panagiotis Zervas and Demetrios G. Sampson</i>	
Chapter 11	
Mobile Learning Operating Systems	141
<i>Christian Glahn</i>	
 PART III: Using Mobile Learning in Education and Training	
Chapter 12	
Orchestrating the Flexible Mobile Learning Classroom.....	161
<i>Chee-Kit Looi and Yancy Toh</i>	
Chapter 13	
Mobile Learning in Higher Education.....	175
<i>Núria Ferran-Ferrer, Muriel Garreta Domingo, Josep Prieto-Blazquez, Cesar Corcoles, Dr. Teresa Sancho-Vinuesa and Mr. Francesc Santanach</i>	
Chapter 14	
Mobile Learning in the Workplace: Unlocking the Value of Mobile Technology for Work-Based Education	193
<i>Christoph Pimmer and Norbert Pachler</i>	
Chapter 15	
Changing the Tunes from Bollywood's to Rural Livelihoods — Mobile Telephone Advisory Services to Small and Marginal Farmers in India: A Case Study	205
<i>Balaji Venkataraman and T.V. Prabhakar</i>	
Chapter 16	
The Future of Mobile Learning and Implications for Education and Training	217
<i>David Parsons</i>	
 Glossary	231

Foreword

Increasing Access through Mobile Learning is a timely book for mobile education, especially for developing countries where the use of mobile technology is increasing at a phenomenal rate. In some developing countries, large numbers of learners are moving directly to mobile devices, bypassing the personal computer stage. As a result, there is tremendous need for learning materials that can be accessed using mobile devices, as a means of opening up opportunities for lifelong learning and professional development.

The book provides valuable insights on how to develop and implement successful mobile learning. Each chapter has been written by one or more experts in mobile learning from around the world.

Part I describes considerations for, and approaches to, designing mobile learning materials. It is important for developers of mobile learning materials to follow standards so that the learning materials can be shared as open educational resources (OER). Delivered on mobile technology, OER have the potential to enable citizens all over the world to access affordable education from anywhere and at any time. Part II of the book discusses how mobile learning can be successfully implemented to maximise access to educational resources with minimum resources, and to maintain flexibility in the delivery process. Part III provides examples of how mobile learning can be used in a variety of settings, including schools, higher education institutions, the workplace and the field, and a variety of contexts, from formal programmes to just-in-time learning.

The book offers a significant contribution to the goal of achieving Education for All, as mobile learning makes it easier to reach citizens around the world regardless of background, culture, location and status. The Commonwealth of Learning (COL) is a global advocate of OER in all spheres of learning. COL has worked with partners on the use of mobile devices in learning for development and has field-tested mobile technology. The combination of OER and mobile learning will revolutionise education, particularly in developing countries. Educators and developers of learning materials must make them available as OER so that education is more affordable. There must be a sense of urgency to develop open materials and systems to deliver learning through mobile technology.

Because the young generation of learners are comfortable using mobile technology and do so on a daily basis, they increasingly expect learning materials to be available through mobile technology. At the same time, the information explosion in many fields means that knowledge is changing constantly. In light of these factors, governments and educational organisations around the globe are more aware than ever of the need to make Internet access more affordable — and eventually free — for all.

Imagine placing a wireless mobile device in the hands of every citizen in the world, granting broad access to OER. Such open access to information and knowledge could vastly improve the quality of countless lives, making the world a more equitable and respectful place.

Professor Asha S. Kanwar,
President & Chief Executive Officer
Commonwealth of Learning

Acknowledgements

The idea for this book was generated because of a mobile learning research project that Professor Mohamed Ally is currently involved with. This research project is funded by Qatar Foundation: Qatar National Research Fund (NPRP Grant # 4-125-5-016).

We thank Qatar Foundation for taking a leadership role in innovation in education and training, and for funding this important mobile learning project.

We also thank the chapter authors, all experts in the field of mobile learning, for contributing to this book.

Dr. V. Balaji (COL) worked closely with the editors to bring out this volume as a publication in the Perspectives series, which enjoys a wide following in the world of open and distance learning (ODL).

Contributors

Mohamed Ally is a professor in the Centre for Distance Education at Athabasca University. He is also a researcher in the Technology Enhanced Knowledge Research Institute at Athabasca University. His current areas of research include mobile learning, eLearning, distance education, and use of information and communication technology in training and education. Ally is a past-president of the International Federation of Training and Development Organisations (IFTDO) and is one of the founding directors of the International Association of Mobile Learning (IAMLearn). He was also on the board of the Canadian Society for Training and Development. Ally chaired the fifth world conference on mobile learning and co-chaired the first international conference on the use of mobile technologies in libraries (m-libraries).

Judy Brown has been involved in technology for learning for over 30 years and with mobile learning since 1996. She now works entirely in the mobile learning area with government, corporations and schools. Judy retired as the Emerging Technology Analyst in the Office of Learning and Information Technology at the University of Wisconsin System. In early 2000, she founded and was Executive Director of the Academic Advanced Distributed Learning (ADL) Co-Lab at the University of Wisconsin System with the U.S. Department of Defense. Following retirement, she continued to support ADL headquarters to build and lead the ADL Mobile Learning Team. She continues to curate the ADL Mobile Learning newsletter while working on specific mobile learning initiatives with Problem Solutions and others.

Cesar Corcoles has been a lecturer at the Computer Science, Multimedia and Telecommunications Department of Universitat Oberta de Catalunya since 2001. He has a BSc in Mathematics from the Universitat Autònoma de Barcelona (2000). His research interests include the use of technology and multimedia to improve the teaching of STEM subjects.

Helen Crompton received her PhD in technology and mathematics education from the University of North Carolina in Chapel Hill, USA. She is currently an assistant professor in the Department of Teaching and Learning at Old Dominion University, Virginia. Crompton studies the field of mobile learning, with a particular emphasis on context-aware ubiquitous learning which is a sub-category of mobile learning. She is also an Instructional Consultant and a member of faculty for the International Society for Technology in Education (ISTE).

Inge Ignatia de Waard is a researcher in mLearning and Massive Open Online Courses (MOOCs), proudly affiliated with Athabasca University, Canada. With a background in IT and pedagogy, she has been involved in eLearning since 1999. She has worked with people from several continents, collaborating on different

e- and mLearning projects. De Waard is also organiser of MobiMOOC, a free open online course on mLearning. She is an author for the Learning Solutions magazine published by the eLearning guild, and writes papers (both academic and other) on a regular basis. She is part of the programme committee of mLearn2012 and IADIS, and collaborator of the Mobile Learning Curriculum Framework (South African initiative). As well, she is a member of the MobiMOOC Research Team, IAmLearn, the mLearnopedia content community, the Advisory Committee of Online Educa Berlin and the eLearning learning content community.

Núria Ferran-Ferrer has been an associate professor at the Information and Communication Sciences Department of Open University of Catalonia (UOC) since 2005 and assistant to the vice-president of Research and Innovation since 2011. She has a PhD in Information Science at Universitat de Barcelona (2010); Bachelor's degrees in Journalism at Universitat Autònoma de Barcelona (1998) and in Information Science (2003); and a Master's degree in Information Society at UOC (2005). Her research areas span from personal information management, and information-related competences in several contexts (eLearning, workplace and daily life) to open educational content and practices.

Muriel Garreta is Director of the Services for Learning department of the Open University of Catalonia (UOC). She was previously a senior product manager and user experience analyst in Office Learning Technologies. She holds a Master's degree in Human-Computer Interaction from Carnegie Mellon (USA), a multilinguism and ICT (information and communication technologies) post-graduate degree from Université Charles de Gaulle – Lille 3 (France), and a Bachelor's degree in Journalism from Universitat Autònoma de Barcelona (Spain). As a director, she works closely with teachers and end-users and leads learning tools development with a holistic and user-centred design approach. Her team includes computer scientists, psychologists, pedagogy experts, graphic designers and usability experts.

Christian Glahn is a researcher at the International Relations and Security Network (ISN) at the Swiss Federal Institute of Technology Zurich, where he specialises in mobile technology learning and research. Prior to joining the ISN, Glahn was an assistant professor at the Centre for Learning Sciences and Technologies (CELSTEC), the Open University, The Netherlands. He holds a PhD in Educational Technologies and a Master's degree in Educational and Computer Sciences. His research interests focus on designing instructional methods and tools that broaden the way we learn, both formally and informally. He has published over 30 peer-reviewed articles on the subject and has been involved in several national and international research and development projects on lifelong learning and educational technologies. Glahn is a member of the Executive Committee of the International Association for Mobile Learning (IAmLearn), and chairs the SWITCH SIG Mobile Learning.

Mike Hruska is a technologist and entrepreneur with experiences spanning standards, emerging technologies, learning and science. He is a former researcher at the National Institute of Standards and Technology in Gaithersburg, Maryland, USA. He is currently the President/CEO of Problem Solutions, and provides learning technology solutions to government, commercial and non-profit organisations.

Andy Johnson has been working in the area of distributed learning for over ten years. He has been involved with the SCORM (Sharable Content Object Reference Model) as a part of the Advanced Distributed Learning (ADL) Initiative. He has also been the architect behind content structures supporting SCORM for various government projects, most notably the first JKDDC (Joint Knowledge Development and Distribution Capability) courses. Johnson is currently Games and Learning Analyst at Problem Solutions.

Chee-Kit Looi is the Head, Centre for Scalability, Translation and Commercialization, and a professor of Education in the National Institute of Education, Nanyang Technological University, Singapore. Looi's school-based research is concerned with the implementation and scale-up of technology-enabled innovations and mobile technologies in Singapore classrooms. His research on seamless and mobile learning has made good progress towards creating a model of 1:1 computing in schools. His work created and transformed the curricula of primary grade levels 3 and 4 science in a primary school in Singapore so that they can harness the affordances of mobile devices for inquiry learning. Because of the good research outcomes, the school has decided to scale up its 1:1 implementation to all classes in the two grade levels and to more subjects. Looi's mobile learning projects are featured in 25 hand-held learning products and research projects in the U.S. and abroad in the U.S.-based Sesame Workshop's 2009 report, "Pockets of Potential: Using Mobile Technologies to Promote Children's Learning."

Rory McGreal is a professor of Computer Technologies in Education at Athabasca University (AU), Canada's open university based in Alberta, Canada. He is also a UNESCO/Commonwealth of Learning chair in Open Educational Resources (OER) and Director of the Technology Enhanced Knowledge Research Institute (TEKRI). He was previously the Associate Vice-President Research at AU. Before going there, he was a supervisor at Contact North, a distance education network in Northern Ontario. He has also worked abroad in the Middle East, Seychelles (Indian Ocean) and Europe. He has been honoured with the Wedemeyer Award for Distance Education practitioner. He researches the implementation and management of distance education systems and networks from technological, pedagogical and policy perspectives. His present research interests include the use of OER and standards in technology-assisted learning, particularly in the development/application of learning objects on mobile devices and the assessment and accreditation of informal learners.

Norbert Pachler is a professor of Education and Director of International Teacher Education at the Institute of Education, University of London. Among his research interests are the application of new technologies in teaching and learning, teacher education and development, and all aspects of foreign language teaching and learning. He has published widely and supervises in all of these fields. Since 2007, Pachler has been the convenor of the London Mobile Learning Group (www.londonmobilelearning.net), which brings together an international, interdisciplinary group of researchers from the fields of cultural and media studies, sociology, (social) semiotics, pedagogy, educational technology, work-based learning and learning design. In the book *Mobile Learning: Structures, Agency, Practices* (Springer: New York, 2010), the group developed a theoretical and conceptual framework for mobile learning around the notion of a socio-cultural

ecology. Norbert also co-edited *Mobile Learning: Towards a Research Agenda* (WLE Centre: London, 2007), *Researching Mobile Learning: Frameworks, Tools and Research Designs* (Peter Lang: Oxford, 2009) and *Work-Based Mobile Learning: Concepts and Cases* (Peter Lang: Oxford, 2011).

Yeonjeong Park has been working as an instructional designer, consultant and researcher for the past ten years. She earned her BSc and MS degrees in Educational Technology from the Ewha Womans University in South Korea; and her PhD in Instructional Design and Technology in the Department of Learning Sciences and Technologies, at Virginia Tech in the USA. Currently, Park is working as a lecturer, teaching instructional methods and technologies in the School of Education at Chonnam National University in South Korea. In the past two years, she has provided human resource development consultation for various companies and done research in smart learning for Samsung SDS. Park has also worked as a manager in the Educational Technology Lab in the School of Education at Virginia Tech. As a member of the instructional design and technology community, Park publishes papers, serves as a journal and conference paper reviewer and presents at international conferences. Her recent research interests include social theories of learning and emerging technologies such as mobile devices, augmented reality, social software and digital games.

David Parsons is an associate professor of Information Technology at Massey University, Auckland, New Zealand. He has a PhD in Information Technology from Nottingham Trent University (UK) and a Master's degree in Computer Science from the University of Southampton (UK), and has wide experience in both academia and the IT industry. He is the founding editor-in-chief of the *International Journal of Mobile and Blended Learning* (IJMBL) and author of a number of texts on computer programming, Web application development and mobile learning. He is an active member of the international mobile learning research community. Parsons chaired the Conference on Mobile Learning Technologies and Applications in 2007 and was co-editor of *Innovative Mobile Learning: Techniques and Technologies* (Information Science Reference, 2009). He also edits the annual compilations of papers from IJMBL that are published as a regular series of books. He is a member of the International Association for Mobile Learning, a committee member of the Australia New Zealand Mobile Learning group (ANZMLearn) and a professional member of the British Computer Society.

Christoph Pimmer is educational researcher, advisor and programme co-ordinator at the learning.lab, University of Applied Sciences, Northwestern Switzerland. His interests include technology-enhanced learning and communication, social and mobile media, computer-supported collaboration, work-based learning, and medical and clinical education. In these fields, Pimmer has worked and led on a number of inter- and transdisciplinary projects in schools, universities and corporate contexts, in Western as well as in developing/transition countries. He is, inter alia, co-editor of the book *Work-Based Mobile Learning: Concepts and Cases* (Peter Lang: Oxford, 2011) and a member of the editorial board of the *International Journal of Mobile and Blended Learning*. Pimmer also participates in several practical and scientific networks centred on innovative forms of learning and education, such as the London Mobile Learning Group and the Swiss Network of Educational Innovation.

Jonathan Poltrack is a software engineer, systems architect and technical project manager with significant experience in online learning technologies. He has contributed to several de facto eLearning standards, including the SCORM, since 1999. He is currently a partner at Problem Solutions and is serving U.S. Government clients in their online learning initiatives.

T.V. Prabhakar is a professor in Computer Science and Engineering at the Indian Institute of Technology in Kanpur, India. He is especially interested in the application of ICT (information and communication technologies) for development, with emphasis on knowledge management. For more information about him, go to www.cse.iitk.ac.in/users/tvp/.

Josep Prieto-Blazquez completed his PhD in Computer Science in January 2009 at the Universitat Oberta de Catalunya and received his Master's degree in Computer Science from the Universitat Politècnica de Catalunya. Since 1998, he has worked as a lecturer in the department of Computer Science, Multimedia and Telecommunication at the Universitat Oberta de Catalunya, where he has been Director of the Computer Engineering (CE) programme since 2001 and Vice-Dean in the same department since 2009. His research focuses on exploratory and application technology in the field of ICT (information and communication technologies). He has also participated in wireless, free software and virtual learning environment projects, and is a member of the Mobility, Multimedia and Multidevice innovation group (mUOC) and of the Kriptography and Information Security for Open Networks (KISON) research group.

Anthony Ralston currently works at the United Nations High Commission for Refugees (UNHCR) at the Global Learning Centre, Budapest, Hungary. He is the Head of Unit for Design & Development and is involved in training strategies for UNHCR staff worldwide. His position involves project management for UNHCR training courses, development of training programmes, design of online and mobile learning, and involvement in strategic training plans for UNHCR duty station offices globally. In addition, he is an associate faculty member in the Education programme at Royal Roads University, Victoria, British Columbia, Canada. Ralston has spoken on topics such as online and mobile learning at the Association of Canadian Community Colleges (ACCC), the Canadian Network for Innovation in Education (CNIE) and UNESCO. His Master's of Professional Education at Deakin University, Australia, encompassed educational leadership, online and distance learning, and specifically, the implementation of online and mobile learning. He holds a Post-Graduate Certificate in Education from the University of Nottingham, UK. He is continuing his EdD studies through Athabasca University to research and prepare his thesis on mobile learning in international settings for humanitarian workers.

Demetrios G. Sampson received a Diploma in Electrical Engineering from the Democritus University of Thrace, Greece, in 1989 and a PhD in Electronic Systems Engineering from the University of Essex, UK, in 1995. He is a full professor of Digital Systems for Learning and Education at the Department of Digital Systems, University of Piraeus, Greece; a Research Fellow at the Information Technologies Institute (ITI), 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, since 1999, Director of the Advanced Digital Systems and Services for Education and Learning (ASK). Sampson has been a visiting

professor at the School of Computing and Information Systems, Athabasca University (2010), at the Information Management Department, National Sun Yat-sen University, Taiwan (2011) and at the University of Tunis (2012, 2013). His main scientific interests are in the area of learning technologies. He is the co-author of more than 280 publications, including scientific books, journals and conferences that have received at least 1,300 known citations (h-index: 20). On seven occasions he has received the Best Paper Award at international conferences on advanced learning technologies. Sampson has been project director, principal investigator and/or consultant in 64 research projects with external funding totalling about €14 million (1991–2016). He is the recipient of the IEEE Computer Society Distinguished Service Award (July 2012).

Teresa Sancho has a PhD in Electronic Engineering from Ramon Llull University (1995). She has been a lecturer in the Computer Science, Multimedia and Telecommunications Department of Universitat Oberta de Catalunya (UOC) since 1998. Sancho is academic co-ordinator and director of the PhD programme in Information and Knowledge Society at UOC, a research director and, currently, Vice-President of Research and Innovation. She is working on three main lines of research: affective and cognitive aspects of online mathematics; transformations of universities' analysis through the use of the Internet, and collaborative networks for educational repositories and teaching communities.

Francesc Santanach has a Bachelor's degree in Software Engineering from the Polytechnic University of Catalonia (UPC). He currently works in the Office of Learning Technologies at the Universitat Oberta de Catalunya (FUOC). He is responsible not only for the design and technical architecture of the FUOC Virtual Campus, but also for the interoperability and integration of eLearning solution and educational resources. Santanach runs national and international projects in the field of education contents, eLearning tools and standards (such as SCORM and IMS QTI platforms, videoconferencing, audio and video blogs, and 3D environments), and integration and interoperability services based on IMS LTI and OKI OSIDs. He has also been a researcher in the eLearning field, author of learning materials, and tutor for the FUOC.

Eileen Scanlon is Regius Professor of Open Education and Associate Director Research and Innovation in the Institute of Educational Technology at the Open University in the UK and is a visiting professor in Moray House School of Education, University of Edinburgh. She has served as co-director of the Open University Centre for Research in Education and Educational Technology, which is one of the leading education research units in the UK. Scanlon has also held visiting academic appointments at the University of California (Berkeley) and the University of London, and consultancies at Xerox Palo Alto Research Centre (PARC) and Rank Xerox Research Centre Cambridge (EuroPARC). She is currently directing projects on learning in formal and informal settings, the development of an inquiry learning pedagogy, and incidental learning frameworks. Funding sources have included the European Commission, UK Economic and Social Research Council, Hewlett Foundation, and Higher Education Funding Council for England, Joint Information Systems Committee. She has published widely on a range of topics, including mobile learning.

Marcus Specht is a professor for Advanced Learning Technologies at the Centre for Learning Sciences and Technologies at the Open University of the Netherlands

and Director of the Learning Innovation Labs. He received his Diploma in Psychology in 1995 and a Dissertation from the University of Trier in 1998 on adaptive information technology. From 1998 until 2001, Specht worked as senior researcher at the GMD research centre on Human–Computer Interaction and mobile information technology. Since 2001, he has headed the Mobile Knowledge department at the Fraunhofer Institute for Applied Information Technology (FIT). He is currently involved in several national and international research projects on competence-based lifelong learning, personalised information support, and contextualised and mobile learning. His research focus is on mobile and contextualised learning technologies, learning network services, and social and immersive media for learning. Specht is a member of ACM, IEEE, and the SIKS and ICO research schools in the Netherlands, and he is an Apple Distinguished Educator.

Geoff Stead is the head of Qualcomm’s Mobile Learning lab, a technology research lab developing new learning tools and championing innovative ways to use mobile and wireless technologies to enhance learning and performance, both at work and at home. He is an internationally regarded learning technologist, involved in workplace mobile learning since 2001. Recent large-scale projects include JKO Mobile (inventing and building a mobile learning platform for the U.S. government), MoLE (multination trials of mobile learning for disaster relief organisations), and OMLET (an open source project allowing for cross-platform mLearning app development). Stead worked on these projects while employed by Tribal UK as Head of Innovation.

Yancy Toh is a research associate with the Learning Sciences Laboratory, National Institute of Education, Nanyang Technological University in Singapore. She is also a doctoral student at the University of Leicester. Her dissertation is examining the systemic influences that impinge on a school’s capacity to sustain technology-enabled pedagogical innovations for student-centred learning. Toh’s research interests include complexity systems, technology leadership and school reforms.

Avgoustos Tsinakos is a professor in the Department of Computer and Informatics Engineering of Eastern Macedonia and Thrace Institute of Technology and he has also served as Coordinator of Master of Distance Education in Greece on behalf of Athabasca University of Canada since 2009. He has several publications to his name and has been the co-ordinator (or member of the co-ordination team) of more than 14 national and international projects on the topic of distance education. Additionally, Tsinakos has participated in a number of international and national conferences as an invited speaker or presenter. In 2011, he joined the Bologna Expert Team, as National Representative on behalf of the Greek Ministry of Education.

Balaji Venkataraman is currently director for Technology and Knowledge Management at the Commonwealth of Learning (COL). For nearly 20 years now, he has been an active worker in the area of ICT (information and communication technologies) applied to rural development. Among his significant work is the development of the first set of “connected” villages in India in the 1990s (funded by IDRC, Canada) and establishment of a series of activities linking farmers and learning in the framework of a virtual academy for the semi-arid tropics. Over the last five years, Venkataraman has been closely associated with agropedia and its ecosystem of projects that use semantic Web technologies and mobile

telephony. Since moving to COL in 2010 from India, he has focused on improved discovery of Open Educational Resources (OER) and their re-use and adaptation, and served on the steering group for the World OER Congress (UNESCO and COL, June 2012). He currently serves on the editorial boards of journals on knowledge management, and on the Global Industry Council affiliated with IFIP. His current interests focus also on deployment of low-cost mobile computing in learning for development.

Panagiotis Zervas 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. He is currently completing his PhD in the Department of Digital Systems, University of Piraeus, Greece. His research interests focus on context-aware mobile learning systems and digital systems for open access to educational resources and practices. He is the co-author of more than 50 publications in scientific books, journals and conferences, which have received at least 60 known citations. On four occasions he has received the Best Paper Award at international conferences on advanced learning technologies. He is a Senior Member of Advanced Digital Systems and Services for Education and Learning (ASK) and he has had ten years of professional experience in research at Learning Technologies. Zervas is also a member of the executive board of the IEEE Technical Committee on Learning Technology, and the Technical Manager of the *Educational Technology and Society Journal*.

Introduction: Enhancing Access to Education with Mobile Learning

Mohamed Ally and Avgoustos Tsinakos

As the use of mobile technology increases around the world, there is growing interest in its use in education and training. This is especially true in developing countries, where citizens are acquiring mobile technology rather than computers, bypassing the desktop and notebook computer stages. Educators and trainers will therefore have to develop learning materials for delivery on a variety of technologies, including mobile devices; and teachers will have to be trained on how to design and deliver mobile learning.

For these reasons, it is important that standards for mobile learning be set so that high-quality mobile learning materials are developed and learning materials can be shared among educational organisations.

This book on the use of mobile technology for flexible delivery is aimed at helping educators and trainers develop and implement mobile learning. It also provides information that researchers can use to conduct research on the use of mobile learning in education and training.

The book is divided into three sections.

Part I covers the design of mobile learning.

- Chapter 1 provides a historical overview of technology contributing to mobile learning and the progression towards student-centred pedagogies. It is important to know the history of mobile technology to get an appreciation of current technology that exists today.
- Chapter 2 addresses educational standards for mobile learning and mobile application development. For portability and development of high-quality mobile learning materials, proper standards must be followed. Standards are evolving constantly, and educators must be familiar with the standards for mobile learning development.

- Chapter 3 proposes a pedagogical framework for mobile learning that is helpful for developing mobile learning materials. The author looks at transactional distance and mobile learning — an important consideration given that most learners completing mobile learning lessons will be mobile while learning.
- Chapter 4 builds the case for why Open Educational Resources (OER) are needed for mobile learning. Many initiatives around the world are working towards the goal of making learning materials available as OER. However, there are still hurdles to overcome to make this a success.
- Chapter 5 presents the Ambient Information Channel (AICHE) model as an approach for building contextualised learning support, and provides guidelines for the development of applications that use sensor information. As learners are mobile, they can use sensors to access information and learning materials to learn in context.
- Chapter 6 describes the connection between mobile learning and interactive design processes through the adaption of transformative learning and self-motivational learning which can enhance the learning experience of the user in a mobile environment.
- Chapter 7 discusses how the particular features of mobile learning can be harnessed to provide new learning opportunities in relation to collaboration-, inquiry- and location-based learning. Mobile learning offers new “scaffolding” possibilities — namely, for building greater collaborations while developing mobile learning’s better-known features, such as enabling effective knowledge transfer between settings and using location-based learning to make learning more relevant.

Part II covers implementation of mobile learning by educators and trainers.

- Chapter 8 provides information on which formats and technologies are best for simplifying the process of moving good mobile learning between different platforms. According to the author, the optimal solution is a “mesh” of various technical approaches, bridging some of the gaps between mobile platforms and improving the portability of the learning apps that run on them.
- Chapter 9 addresses the challenges that are affecting mobile learning and emphasises the need to embed mobile learning in the overall learning environment. The author describes the learning opportunities that Bring Your Own Device (BYOD), mobile social media, mobile apps and mobile sensors offer for mobile learning.
- Chapter 10 explores the current landscape of available commercial and open-source mobile course players, and presents an open-source mobile course player suitable for delivering courses.
- Chapter 11 addresses the common characteristics of mobile learning operating systems (learning management and learning orchestration systems) that can be used to design new solutions and improve existing solutions for mobile learning.

Part III covers mobile learning in education and training and future directions.

- Chapter 12 explores the issues and problems faced by teachers when they implement mobile learning curricula in the classroom. The authors also describe the complexities of “designing for orchestration,” presenting an example of a “mobilised” primary school science curriculum that runs on smartphones.
- Chapter 13 provides a general overview of successful mobile learning experiences and best practices in higher education. In higher education, mobile applications add another layer to the learning and teaching processes and several mobile learning applications have been designed in order to enhance these processes.
- Chapter 14 explores the use of mobile learning in the workplace and describes how mobile devices allow for rich pedagogical strategies in the workplace. The authors suggest that mobile devices can connect and span different situations and forms of learning and, accordingly, support learners across various contexts and phases of their career trajectories. The authors also point out how the use of mobile learning for lifelong learning is an area that needs further exploration.
- Chapter 15 describes an initiative that uses a wide range of open source software to develop Web-to-mobile and mobile-to-mobile voice and text messaging applications. These are used by agricultural experts to form interest- or commodity-specific groups of farmers who regularly receive group-specific messages from the local expert. Activities take place over widely varied agro-ecological zones covering dozens of crops, and across the three language regions of India.
- Chapter 16 discusses the future of mobile learning by addressing the challenges and opportunities of using mobile learning. These should stimulate further research on mobile learning and so contribute to the successful implementation of mobile learning.

As mobile technologies become more advanced and user-friendly, they can be used to deliver education and training in a variety of contexts. At the same time, as more individuals around the world acquire mobile technology, educators and trainers must design and deliver learning materials on mobile technology. Furthermore, the upcoming generations of learners will expect to learn using mobile technology.

Many countries have major initiatives to provide mobile technologies to their citizens, which is in keeping with the Commonwealth of Learning’s mandate and UNESCO’s goal of Education for All in the 21st century. For example, Qatar is funding major research projects in the use of information and communication technologies (ICT) and mobile learning in education and training, including a research project in workplace learning.¹ Brazil is providing tablets to teachers, and the United Arab Emirates, South Korea and Thailand are providing tablets to students. The availability of OER and the increasing use of mobile technology for mobile learning are removing barriers to education and will revolutionise education to allow affordable education for everyone.

¹ “Using Mobile Technology for English Training in the Qatar Workplace.” NPRP Grant # 4-125-5-016 from the Qatar National Research Fund (a member of Qatar Foundation).

Mobile learning is an emerging field that requires more research and development if the potential of mobile learning to education and training is to be realised. This book contributes to the advancement of the mobile learning field, by presenting up-to-date, comprehensive information about the state of mobile learning today and about the design and implementation best practices now in place across the field.

PART

I

Designing Mobile Learning

A Diachronic Overview of Technology Contributing to Mobile Learning: A Shift Towards Student-Centred Pedagogies

Helen Crompton

Abstract

This chapter provides a brief historical overview of the technology contributing to mobile learning (mLearning) and the concomitant progression towards student-centred pedagogies. To begin, mLearning is defined. The theoretical, pedagogical and conceptual underpinnings of it are then explained, with a focus on the technologies and the pedagogies of each decade, from the 1970s and Kay's futuristic vision of a mobile learning device, to today's mobile learning technologies that have surpassed Kay's vision.

Introduction

Mobile learning (mLearning) is a relatively new field of learning. It is embryonic in nature, still changing form and growing. It is pushing the boundaries of traditional pedagogies and challenging epistemic beliefs. Although it may seem that mLearning has appeared from nowhere, its foundations have developed over many years. Other technological innovations such as Gutenberg's printing press and the Industrial Revolution were significant building blocks in this movement. However, to pinpoint the specific time when mLearning was conceptualised, we need to look back to the 1970s. Understanding the theoretical, conceptual and pedagogical underpinnings of mLearning from its early years through to the present day will help readers appreciate how this technological epoch has transformed the didactic world.

This chapter provides an overview of mLearning, studying each decade in regard to the technological innovations and the pedagogical change during that period. Revealed through this discussion is how the development of technological devices parallels pedagogical progression towards student-centred learning.

Defining Mobile Learning

Before studying the conception of mLearning, it is essential for one to know what the term means in order to understand what the field encompasses. Many scholars and practitioners have tried to define mLearning, but as the field is still changing, and will be for many more years, many different definitions have been provided to recognise those changes. For example, mLearning:

- is using the Palm (an early brand of mobile technology) as a learning device (Quinn, 2000; Soloway et al., 2001).
- is any sort of learning that happens when the learner is not at a fixed, pre-determined location, or learning that happens when the learner takes advantage of learning opportunities offered by mobile technologies (O'Malley et al., 2003).
- is a form of eLearning that specifically employs wireless communication devices to deliver content and learning support (Brown, 2005).
- is any educational provision where the sole or dominant technologies are hand-held or palm-top devices (Traxler, 2005).

From this list, it is clear which technologies were used during specific periods of time, and that even Traxler's 2005 definition is already dated with some of today's mobile technologies (such as the iPad) not fitting this definition. The definitions used as examples do have many common elements. Nonetheless, to determine what should be included in the definition of mLearning has been an ongoing debate (e.g., Laouris & Eteokleous, 2005; Sharples, Taylor, & Vavoula, 2007; Traxler, 2009). This debate will not end soon, and further research is needed to understand what mLearning encompasses (Goh & Kinshuk, 2006).

However, from a review of the literature, four central constructs of mLearning have emerged: pedagogy, technological devices, context and social interactions (Crompton, in press). Given these four constructs, mLearning might therefore be defined as: learning across multiple contexts, through social and content interactions, using personal electronic devices (Crompton, in press). Over the next few pages, this definition and the four constructs of mLearning will be used in considering the technologies and the pedagogies of each decade. First the technology will be described, then the pedagogy, before the two are discussed together.

Evolution by Decade

1970s

Many groundbreaking developments in the field of technology took place in the 1970s, and the concept of mLearning was also conceived. During this decade, the first mobile phone was developed, as was the first microcomputer, VHS video-cassette recorder and floppy disc. That phone — the DynaTAC 8000X, developed by Motorola in 1973 — was the first mobile telephone a user could carry without also needing to carry a large, heavy briefcase battery. In this period, technology also merged with telecommunications, with the first public analogue software switchboards appearing in the mid-1970s.

This was also the decade in which Alan Kay had a vision for a new type of computing that was much smaller and personalised. Kay's vision was directly inspired by Moore's Law, which states that due to advancements in the miniaturisation of microchip manufacturing, the computing power of these tiny chips would double roughly every 18 months (Maxwell, 2006). With Moore's Law, Kay determined that the work that was typically accomplished on large machines would soon be possible on small and even portable devices. Kay's small portable computer ideas led to the conceptualisation of the Dynabook. Kay's Dynabook was small and light enough to be easily transported, with the ability to conduct multiple tasks and "enough power to outrace your senses" (Kay & Goldberg, 2001). This revolutionary device had a number of particular attributes (Kay & Goldberg, 2001, p. 167):

"Imagine having your own self-contained knowledge manipulator in a portable package the size and shape of an ordinary notebook. Suppose it had enough power to outrace your senses of sight and hearing, enough capacity to store for later retrieval thousands of page-equivalents of reference materials, poems, letters, recipes, records, drawings, animations, musical scores, waveforms, dynamic simulations, and anything else you would like to remember and change."

Kay's Dynabook was never actually created, but Kay and Goldberg's research led to prototype desk computers which they called interim Dynabooks (Kay & Goldberg, 2001, p. 168). Kay and Goldberg also developed a programming language called SmallTalk. This object-oriented software language resulted in the later invention of the graphical user interface (GUI) used on computers, portable media players and other hand-held devices. The GUI was a significant technological invention: the pictorial icons of the GUI enabled novice computer users to easily access and run the programmes without having to use command strings.

Kay's Dynabook was largely influenced by the work of Seymour Papert. At that time, Papert was conducting research on school children as they worked with Logo language on computers. As the students used Turtle Geometry via a computational medium (Logo), they were able to manipulate geometric constructs concretely, thus bridging the divide between the concrete and formal cognitive stages described by French psychologist Jean Piaget (Papert, 1980a, 1980b). Kay held an educational vision for young children where the Dynabook could provide cognitive scaffolding for exploring the story text, as Turtle Geometry had for mathematics.

Student exploration was a key idea in education during the 1970s. The term "discovery learning" was coined, based on the idea that students are more likely to remember facts that they deduce themselves. This built on Bruner's (1966) belief that students use past knowledge during the active learning process. This moved away from the behaviourist stimulus-response approach to a focus on students acquiring, retaining and recalling knowledge. However, during the 1970s, information and communication technologies (ICT) were scarcely seen in schools. The few students using technology in schools were typically using behaviourist computer-assisted learning programmes (Lee, 2000).

1980s

This decade heralded the arrival of hand-held computers, which were marketed and used within the business setting. For example, in 1980, the TRS-80 Pocket Computer from Radio Shack boasted a 24 × 1 text LCD display with 1.5 kB RAM. In 1983, Commodore Business Machines developed the HHC-4 (Hand-Held Computer), featuring a 24-character LCD screen with 4 kB RAM which was expandable to 16 kB. As this decade progressed, so did the hand-held technologies. In 1989, Atari Computer featured the Portfolio portable computer. This device, the size of a video-cassette, included a keyboard with an eight-line, 40-character wide LCD display. The Portfolio boasted 128 kB RAM and allowed the user to store information externally on memory cards. The device included a word processor, spreadsheet, calendar, calculator and address book.

These hand-held computers were becoming increasingly more personalised, and were typically marketed for the individual rather than for shared use. Telephones were becoming more personalised, which resulted in a boom in personal mobile phone sales. Mobile phones became more portable, smaller and customisable to the individual (Goggin, 2006). Computers were also becoming more personalised with the first commercial laptop computer introduced to the market in the early 1980s. These computers often replaced the static tethered home computers. Towards the end of the 1980s, some schools and higher education establishments began to make the connection between technology and the student-centred personalised learning they sought to achieve, and allowed students to bring laptops into lecture halls for note-taking purposes.

Building from the discovery-learning approach of the 1970s, the 1980s moved into constructivist and constructionist learning. In keeping with Bruner's (1966) educational philosophies, constructivism is student-centred, "proposing that learning environments should support multiple perspectives or interpretations of reality, knowledge construction, context-rich, and experience-based activities" (Jonassen, 1991). Constructivists posited that students not only bring and use their prior knowledge, but also build on that knowledge using authentic tasks. "The computer was no longer a conduit for the presentation of information: it was a tool for the active manipulation of that information" (Naismith, Lonsdale, Vavoula, & Sharples, 2004, p.12).

Papert (1980b) proffered that an additional component be added to constructivist learning: students not only learn by building from their prior knowledge conducting authentic tasks, but also that they use that knowledge to produce new ideas. Papert added that students will be most likely to do this when they are able to create some type of external artifact. For example, students could use technology to teach Karel the Robot to perform tasks in Microworlds, or use Logo to teach the computer to draw a picture. This connects with Taylor's (1980) tutor, tool, tutee computer analogy, as students would take the role of the tutee.

A key feature of constructionist learning is not just that the students are creating external artifacts, but that those artifacts are to be shared with others. The student-centred learning of the 1970s was focused on connecting learning with the knowledge and experiences of the students. The 1980s added to this student-centred approach by having the students actively involved in learning using

authentic tasks and in creating artifacts to interact with the environment and society in sharing those artifacts.

During the 1980s, schools were beginning to get more computers for the students to use. Computer-Assisted Instruction (CAI) was gaining in popularity. CAI involved students interacting with computer programmes to solve problems and work through tutorials. The most common CAI programmes were drill-and-practice programmes. The affordances of technology in education were beginning to be recognised by many. Computers were described as infinitely patient tutors, tough examiners and tutors who allowed students to work at their own pace (Kulik, Kulik, & Cohen, 1980). CAI connected with the constructivist methodology, as the students were involved in the learning process through interaction (Chambers & Sprecher, 1980) and the immediate feedback from the computers often led to an increase in student motivation (Feurzeig, Horwitz, & Nickerson, 1981). A move towards more personalised learning was highly valued.

1990s

This decade heralded the use of many new technologies. The first Web browser was developed, as well as the first digital camera and graphing calculator. Multimedia computers were available for student use in many schools. The desire to personalise devices and learning was duly noted by commercial vendors. Portable digital devices were developing rapidly and PalmPilots, a form of personal digital assistants (PDAs), were the first multipurpose hand-held devices that could be used in an educational setting. These hand-held devices included calculators, memos, contacts, notepad and photos.

As the hand-held technologies developed, Sharples made an attempt to actualise Kay's Dynabook. The Handheld Learning Resource project (HandLeR) developed a prototype personal hand-held computer to demonstrate the concept and feasibility of such a mobile device for experiential learning (Chan & Sharples, 2002). As Sharples (2000) wrote, this mentor system:

“would suggest ways of studying and set up systems for organising resources and remembering ideas and events; it can provide long-term guidance on developing skills, particularly where the mentor could have direct access to the technology needed for performing the skill (such as the Worldwide Web, or a digital camera); it can act as a learning assistant in performing tasks or solving problems, but suggesting new strategies and solutions.... A computer-based mentor need not reside in a single piece of hardware; it might migrate across different physical devices, but retaining the persona and knowledge of the learner.”

Sharples' (2000) vision was similar to what mobile technologies are available today.

With the pedagogical drive towards student-centred learning, there was a call for designers of educational technologies to consider how technologies could be used to meet these pedagogical efforts. Soloway, Guzdial, and Hay (1994) posited three key questions for designers: “Why support learners and learning? How might the interface support learners and learning? What are the issues involved in providing such support?” These were essential questions that needed to be asked during a time of ICT adoption in schools.

Continuing the theme of social sharing of artifacts within the 1980s constructionist era, the 1990s developed socio-constructivist learning with proponents who posited that intellectual advancement develops through scholarly interactions with others. This pedagogical philosophy particularly benefited from the social adoption of the World Wide Web during the 1990s. Early websites were static in nature and offered little interaction from the users, but they did offer a method of uploading artifacts to be viewed by the worldwide audience. The nature of distance learning changed as technology enabled lecturers to teach groups as well as individuals through the World Wide Web, changing the name to electronic learning (eLearning).

The pedagogy in the 1990s also shifted towards problem-based learning, which involved students working on authentic problems within applicable environments. This caused many field-based experiences to ignore technologies as they were too cumbersome to carry around to different locations. Thus, mobility became a desirable technological attribute.

2000s to Present Day

During the past decade or so, the changes in educational technologies have risen exponentially and the majority of these advancements correlate to the demand for student-centred learning. The call for personalised learning has increased with mounting pressure from educators and from society, which has grown accustomed to a personalised existence. The mobile phone that was once a symbol of status became an everyday tool for the masses. The phones became smaller and more affordable, and now provide many of the same capabilities of microcomputers.

As the 2000s progressed, the read-only Internet changed to the dynamic interactive “read-write web” (Richardson, 2005), allowing users to create and interact with content. Great banks of digital artifacts were made available through the Internet as libraries and museums digitised their collections (Benedek, 2007). Web 2.0 tools included methods to use social theories of learning with networks such as Facebook and Ning to communicate personally and professionally, as well as virtual learning environments (VLEs) such as Blackboard and Moodle to allow students and educators to mediate Web-based artifacts and communication.

As society grew accustomed to the smartphone capabilities and Internet access, the demand also grew for a variety of features for different tasks. Although smartphones were portable and provided an easy way to access the Internet, students found the screen size made it hard to read large amounts of text because of the constant need to scroll or make the text larger (Crompton & Keane, 2012). Tablets were introduced to provide both the portability and large screen. The early tablets were laptops with the ability to swivel the screen to sit neatly on top of the case with touch-screen capabilities, such as the Microsoft Tablet PC which was available to the public in 2001. Ultra Mobile PCs (UMPCs), such as the Wibrain B1, were developed and quietly introduced to the public in 2006. These UMPC were lighter and more portable than the original tablets, but still retained a larger screen. However, these mobile devices were quickly replaced by today’s tablets, such as the iPad and Motorola Zoom, which are thinner, lighter and again more mobile.

These mobile devices are extending the boundaries of traditional pedagogies towards student-centred educational practices. Students using various technologies

can have the choice of what they learn and how fast they go through the material. Today, students also have the choice of when and where they choose to learn. In the past, technology was seen as an expensive option for educational establishments. However, with the ubiquitous use of mobile technologies in today's society, many establishments are choosing to adopt Bring Your Own Technology (BYOT) initiatives. The BYOT approach allows students to learn with whichever mobile device best meets their needs, with little to no cost to the educational establishment. Both the device and the pedagogy are geared towards student-centred learning.

Conclusion

This chapter provides a brief historical overview of technology and mLearning and the concomitant progression towards student-centred pedagogies, from Kay's 1972 vision of students working with the Dynabook in 1972 to present-day technologies that have even surpassed Kay's futuristic ideas. Nonetheless, during those early years, Kay worked with a group from Xerox to create the Dynabook as a business computer called the Star (Sharples, 1998). The business community could not see any use for this strange machine and the concept was unsuccessful. Society was not prepared for such a tool.

It would appear that the technologies used in schools have been well aligned to the pedagogical theories of that time towards student-centred learning. There has been rapid progress in technological affordances over the past few decades, and it will be interesting as to what the future may bring.

References

- Benedek, A. (2007). Mobile learning and lifelong knowledge acquisition. In K. Nyiri (Ed.), *Mobile studies: Paradigms and perspectives. Communications in the 21st century* (pp. 35–44). Vienna: Passagen Verlag.
- Brown, H. T. (2005). Towards a model for MLearning. *International Journal on E-Learning*, 4(3), 299–315.
- Bruner, J. S. (1966). *Toward a theory of instruction*. Cambridge, MA: Harvard University Press.
- Chambers, J. A., & Sprecher, J. W. (1980). Computer assisted instruction: Current trends and critical issues. *Association for Computing Machinery*, 23, 332–342.
- Chan, T., & Sharples, M. (2002). A concepts mapping tool for pocket PC computers. In *Proceedings of the IEEE International Workshop on Wireless and Mobile Technologies in Education (WMTE'02)* (pp. 1–2).
- Crompton, H. (in press). A historical overview of mobile learning: Toward learner-centered education. In Z. L. Berge & L. Y. Muilenburg (Eds.), *Handbook of mobile learning*. Florence, KY: Routledge.
- Crompton, H., & Keane, J. (2012). Implementation of a one-to-one iPod touch project in a middle school. *Journal of Interactive Online Learning*, 11(1), 1–8.
- Feurzeig, W., Horwitz, P., & Nickerson, R. S. (1981). *Microcomputers in education*. Cambridge, MA: Bolt, Beranek, & Newman Inc.

- Goggin, G. (2006). *Cell phone culture: Mobile technology in everyday life*. New York: Routledge.
- Goh, T., & Kinshuk, D. (2006). Getting ready for mobile learning-adaptation perspective. *Journal of Educational Multimedia and Hypermedia*, 15(2), 175–198.
- Jonassen, D. H. (1991). Evaluation constructivistic learning. *Educational Technology*, 31, 28–33.
- Kay, A. C., & Goldberg, A. (2001). Personal dynamic media. In R. Packer & J. Jordan (Eds.), *Multimedia: From Wagner to virtual reality* (pp. 167–178). London: W. W. Norton & Company. (Original work published 1977.)
- Kulik, J. A., Kulik, C. C., & Cohen, P. A. (1980). Effectiveness of computer-based college teaching: A meta-analysis of findings. *Review of Educational Research*, 50(4), 525–544.
- Laouris, Y., & Eteokleous, N. (2005, Oct. 25–28). *We need an educationally relevant definition of mobile learning*. Paper presented at the 4th World Conference on mLearning, Cape Town, South Africa.
- Lee, K. W. (2000). English teachers' barriers to the use of computer-assisted language learning. *The Internet Teachers of English as a Second Language Journal*, 6. Retrieved December 30, 1999, from <http://202.200.82.45/englishonline/jxyj/iteslj/Lee-CALLbarriers.html>
- Maxwell, J. W. (2006). *Tracing the Dynabook: A study of technocultural transformations*. Unpublished doctoral dissertation, University of British Columbia.
- Naismith, L., Lonsdale, P., Vavoula, G., & Sharples, M. (2004). Literature review in mobile technologies and learning. In *NESTA Futurelab Literature review series* (Report 11). Retrieved November 5, 2011, from <http://archive.futurelab.org.uk/resources/publications-reports-articles/literature-reviews/Literature-Review203>
- O'Malley, C., Vavoula, G., Glew, J., Taylor, J., Sharples, M., & Lefrere, P. (2003). *Guidelines for learning/teaching/tutoring in a mobile environment*. MobiLearn Deliverable 4. Retrieved from <http://mobilelearn.mobi/>
- Papert, S. (1980a). *Mindstorms: Children, computers, and powerful ideas*. New York: Basic Books.
- Papert, S. (1980b). Teaching children thinking. In R. Taylor (Ed.), *The computer in the school: Tutor, tool, tutee* (pp. 160–176). New York: Teachers College Press. (Original work published 1972.)
- Quinn, C. (2000). *mLearning: Mobile, wireless, in-your-pocket learning*. Retrieved from www.linezine.com/2.1/features/cqmmwiyp.htm
- Richardson, W. (2005). The educator's guide to the read/write web. *Educational Leadership*, 4, 24–27.
- Sharples, M. (1998). Why did you bother to write a book? Retrieved from www.eee.bham.ac.uk/sharplem/Routledge/article.htm
- Sharples, M. (2000). The design of personal mobile technologies for lifelong learning. *Computers and Education*, 34(3–4), 177–193.

- Sharples, M., Taylor, J., & Vavoula, G. (2007). A theory of learning for the mobile age. In R. Andrews & C. Haythornthwaite (Eds.), *The sage handbook of elearning research* (pp. 221–247). London: Sage.
- Soloway, E., Guzdial, M., & Hay, K. E. (1994). Learner-centered design: The challenge for HCI in the 21st century. *Interactions*, 1(2), 36–48.
- Soloway, E., Norris, C., Curtis, M., Jansen, R., Krajcik, J., Marx, R., Fishman, & Blumenfeld, P. (2001). Making palm-sized computers the PC of choice for K–12. *Learning and Leading with Technology*, 28(7), 32–57.
- Taylor, R. (Ed.). (1980). *The computer in the school: Tutor, tool, tutee*. New York: Teachers College Press.
- Traxler, J. (2005, June). *Defining mobile learning*. Paper presented at the IADIS International Conference on Mobile Learning 2005, Qawra, Malta.
- Traxler, J. (2009). Learning in a mobile age. *International Journal of Mobile and Blended Learning*, 1(1), 1–12.

Educational Standards for Mobile Learning and Mobile Application Development

Judy Brown, Michael Hruska, Andy Johnson and Jonathan Poltrack

Abstract

Standards have played an important role in the evolution of technology and, more specifically, the Internet. As the ubiquity of mobile devices continues to grow, so does the opportunity to leverage their portability and connectivity for learning. An evolution of various standards has unfolded to support the use of mobile devices in our daily lives. The World Wide Web Consortium (W3C) has published practices on mobile Web best practices and content transformation. Other practices, such as responsive Web design (RWD), allow designers the opportunity to consider the broader implications of interface design in the context of all types of display formats. While most of the standards serve to support device connectivity, communication and transport, a small number are directly related to learning and content.

As we move forward, the de facto Web standard HTML, with roots in formatting typesetting, and the eLearning specification, the Sharable Content Object Reference Model (SCORM) that is rooted in tracking content in the browser, provide two points of departure for the future development of mobile learning (mLearning). HTML5 (the new version of HTML) and the Experience API (the successor to the SCORM) are defining a base from which content development, delivery and tracking can be better defined for mLearning. Furthermore, HTML5 is currently proliferating in the marketplace while the Experience API is evolving as a formal specification published as a 1.0. In concert, they will provide the community with the necessary capabilities to further mLearning.

Standards already in existence should begin to have a greater effect on mLearning. Standards related to near field communications (NFC) will likely support more use cases in mLearning as the number of devices and amount of demand for mLearning continue to grow. Additionally, concepts like the “Internet of things”

(IOT) should evolve into complimentary standards and specifications that will connect learning, mobile devices and the world around us.

Introduction

Standards play an important role in all aspects of our lives. For instance, standards and specifications have paved the way for the ubiquity of mobile devices in today's society. The opportunity that mobile devices, coupled with broad connectivity, provides for learning is significant and expanding. The mobile platform has taken access to resources at the time of need to a new level, and has enabled new environments where learning can be accomplished and where learning experiences can be injected. A large number of standards support the use of mobile devices, yet only a small number define how to use them for learning. It is important to take a look at the evolution of standards supporting mobile device usage, current efforts related to content and tracking, and potential future efforts.

A Tale of a "Standard"

There is a long-standing urban myth circulating about standards that is often assumed to be true. This myth connects the standards used in the space programme to the origins of the dimensions of chariots in ancient Rome, and how those chariots' standards influenced roads in England, and railroads in the United States. The following is a truncated conversation about the myth as originally overheard at a workshop:

Greg: "Do you know how wide railroad tracks are?"

Donny: "Yes, four feet, eight-and-one-half inches."

Greg: "Why are they that wide?"

Donny: "Well, Greg. Railroads in the U.S. were built by Englishman who imported the width specification from English railroads."

Greg: "Why are they that wide in England?"

Donny: "Oddly enough, railroads in England were built atop roads originally built for Roman chariots. The chariots created defined ruts that allowed nothing but wheels of a certain width to operate without breaking. The original railroads in England were built on these roads according to the width of wheels that worked."

Greg: "Interesting, but why were Roman chariots that wide?"

Donny: "Because the military specification for chariots was developed in Rome as the standard around the width of Roman horses."

While the story is interesting, a number of claims counter its factual basis with a significant likelihood of fabrication and embellishment (Lowell, 2001). Nonetheless, it does represent the notion that, unintentionally, the needs of one community can lay the groundwork for a number of dispersed and unintentional consequences of another. This example, though urban legend, provides a base from which to think about standards as additive, evolving and enabling. The concept of standards in this fictional case, though built for one use, were able to be translated elsewhere and repurposed to ultimately enable other capabilities.

Why Standards?

Standards play an important role in everyday life. Everything we take for granted — from standard light bulbs and batteries to the width of roads — could be significantly disrupted without the uniformity produced by consensus around a standard. Imagine driving down the road, crossing a boundary and finding the road 60% of the width required to drive: that could prove problematic. Even worse, imagine that the acceleration due to gravity, which permeates much of our assumptions of our world, was more inconsistent and unpredictable than the very slight anomalies that already occur. Basic activities, such as driving and walking, and complex activities, such as construction and space travel, would be adversely affected. The resulting unpredictability would disallow many affordances of such standards we take for granted. Thus, it's clear to see that standards are important parts of maintaining assumptions and expectations.

In many ways, these standards (when they work well) operate in the background of end-users' lives. Signs and specifications aren't often present to remind anyone of the common place that standards have for providing structure, balance and predictability in our lives. The eventual implicit nature of these standards could arguably be the result of properly leveraging standards to build products, as well as the undeniable utility of good standards, or a combination of both. The bottom line: standards should operate in the background of the end-users' worlds.

Standards are commonly related to health, safety, environment and technology. Furthermore, standards are broken down into two types:

1. **De jure standards** are defined by a group through a process, and then obligatory conformance is imposed. Examples include standards developed by the International Standards Organization (ISO), such as ISO 9001, through a rigorously defined process (Wikipedia–De Facto standard, 2012).
2. **De facto standards** are the result of commonly accepted behaviours or practices. Examples include the QWERTY keyboard and MP3 (Wikipedia–De Facto standard, 2012).

Sometimes a standard will start as de facto and evolve to de jure. This happens in cases where industry acceptance of a standard is so wide that recognition and formal obligation are imposed. Examples of this include HTML and PDF.

Standards drive many marketplaces and, conversely, many marketplaces have driven standards. Looking ahead at the effect of standards on mobile learning (mLearning), we will see the effects of de facto, de jure and evolved standards.

Internet and Electronic Learning

When discussing mobile standards and mobile standards for learning, it is important to look at the emergence of the Internet and the standards that formed to support learning on the new platform. In the late 1990s, several important efforts contributed to the state of online learning today. At that time, online learning resembled the Wild West, an unregulated opportunity space. Many people recognised value in using the Internet for learning and training, but widely accepted standards were not in place. The learning and training communities saw this inevitable path, but no single technology, standard or approach ruled the landscape. As a result, “courses” could only be used by the creator organisation,

since learning content worked on the specific system it was designed for and was not exportable from system to system.

As a clear line formed between learning content and learning systems, many organisations created their own specifications for interoperability mainly to save time and money on a smaller scale. For example, if a company had several locations and wanted to re-use a course at each location, it might be useful to define a common run-time environment to track items such as scores, pass/fail and complete/incomplete. Consequently, if a specific environment supported this feature, learners could be tracked when taking a course regardless of where the course was deployed. This was early interoperability at last.

Organisations such as the Aviation Industry CBT (Computer-Based Training) Committee (AICC) and the IMS Global Learning Consortium created specifications for their stakeholders. This important step created the components of a complete solution as well as a community to implement and use the technology. Over time, technologies were refined and communities expanded, thus setting the stage for the first complete solution.

In 1999, the Advanced Distributed Learning (ADL) Initiative was created by President Bill Clinton with the mission to modernise learning and training in the Department of Defense (DoD) (ADL, 2003). One of the ADL's goals was to “establish guidelines on the use of standards and provide a mechanism to assist DoD and other Federal agencies in large-scale development, implementation, and assessment of interoperable and reusable learning systems” (ADL, 2003). As a result of this mandate, the Sharable Content Object Reference Model (SCORM) emerged. The SCORM referenced other organisations' specifications in a single document using an approach called an application profile, which contains policies and best practices used, in addition to a core specification (Wikipedia–Application Profile, 2012). The SCORM application profile referenced these external specifications but also put further restrictions on them to provide a thorough set of conformance requirements, ultimately promoting interoperability.

Through the 2000s the SCORM and other learning specifications and standards frameworks were adopted by online learning content developers globally. Learning management system (LMS) vendors, content developers, authoring tools and the online learning community at large saw the utility of these standards and leveraged them to create and deliver content across industries and sectors. Specifications like the SCORM facilitate interoperable online learning, which ultimately saves time and money. By leveraging the replicability that is enabled by the specifications and standards like the SCORM, entire courses, pieces of courses or even small technical assets are able to be re-used and reassembled into new courses quickly and easily while ensuring the resulting content will work in any conforming system.

This trend marked a major milestone for creating and measuring learning using a browser on a desktop or laptop computer. All of these widely adopted specifications and standards were created before smartphone technology. Although it is possible to use existing learning standards with mobile phones, they were never designed for, or intended to be used on such a platform. As a result, workarounds, middleware and other “partial-hacks” are deployed to use mobile devices with existing learning platforms. These patchwork solutions

are indicative of the need to establish specifications and standards that directly support mLearning.

Mobile Standards and Practices

The term “mobile” means a variety of things to people. For some, it is merely the act of taking a communication device off a wired infrastructure. Others see it as moving electronic content from a larger device to a smaller one. Those most invested in exploiting mobile devices to deliver training and learning opportunities see the term as something entirely different — a complete paradigm shift in the way we learn with supporting devices. This shift means not only a change in the way we display content, but in the way it is structured, presented, consumed and assessed. This fully vested departure from online or computer-based learning strategies is heavily influenced by the awareness that mobile devices are able to take advantage of the learner’s surrounding environment in ways that traditional eLearning cannot.

Whatever your flavour of “mobile” is, the idea of establishing best practices and standards is indisputably important. This section provides an overview of what best practices and standards have existed and what exists now for mobile technology. The first set of standards to look at is the primary function of most mobile devices — communication.

To make an actual call using a mobile device, one of two competing standards is called for: Time Division Multiple Access (TDMA) or Code Division Multiple Access (CDMA). Each standard and corresponding technology has a different solution to the same problem — namely, letting as many users as possible use a given frequency. TDMA simply splits the signal by time slots, whereas CDMA assigns a code that separates users. Each is valuable and effective, as evidenced by the fact that each has major carriers using the standard and enabling technology. TDMA was later replaced with Global System for Mobile (GSM) and, starting with 2G, is how we see the evolution of such standards moving forward (currently 4G is the highest possible in this line). GSM also incorporates another form of communication technology, Short Message Service (SMS), which is the standard for sending text messages. SMS was developed within GSM but can now function outside that realm. In 2011, SMS had over 3.6 billion active users, making use of agreed-upon practices all the more important (About.com, 2012; Ahonen, 2011).

While large-scale communication that spans the globe is important, short-range communication that doesn’t depend on large-scale infrastructure is also important. Bluetooth and Wi-Fi (also called IEEE 802.11) are two technologies that allow communication across devices in a much shorter area, but with the benefit of not needing to have a signal leave that area (Wikipedia–IEEE, 2012).

Person-to-person and even device-to-device communication protocols are important, but as mobile technology capabilities expand, so too does the ability to design to their user-interfaces. Content specifications that existed for browsers on typical computer operating systems have a rich history, which involves many of those same standards migrating to mobile, albeit with varying degrees of success. HyperText Markup Language (HTML) is the most notable of display mechanisms, as most webpages use this protocol to display content. A standard that goes on top of HTML is Cascading Style Sheets (CSS), which offer more power and flexibility

than HTML tags alone. Mobile technology has successfully imported the pair. In a similar way, many audio- and video-formatting standards, such as MP3 and MP4, have migrated from PC to mobile (Wikipedia–HTML, 2012).

Once a common mechanism for displaying Web content on a device has been established, the structure, instruction and tracking of that content — for learning or otherwise — can be implemented. The World Wide Web Consortium (W3C) provides a wealth of standards and best practices for developing Web applications and Web best practices, and for using Web technology. OASIS's Darwin Information Typing Architecture (DITA) allows the classification and sorting of data in a standardised hierarchy. The SCORM has proven to be extremely valuable in the tracking of learning data in a browser-based system prior to mLearning, but needs to be updated to accomplish the same feat on mobile devices (ADL, 2003; OASIS, 2012; W3C, 2012).

Drawing upon lessons learned through the evolution of computer-based learning standards, the development of a unique set of best practices, specifications and standards for mobile devices should not simply re-appropriate the SCORM or other eLearning frameworks. Standards designed for use on mobile devices should allow the improvement of learning content and opportunities — not just replicate the same methods used in eLearning on a more convenient or accessible device. The major benefit of a mobile device is that one's real-time location matters. For instance, the Global Positioning System (GPS) allows a phone to reveal its location, which in turn can be co-ordinated with content to return more relevant information. Quick Response (QR) codes take information embedded within a picture and can extract them, serving as a relay point for a much larger amount of information. Similarly, radio-frequency identification (RFI) embedded devices can react when brought in proximity with a corresponding device. A common example of this is being able to pay a toll without stopping. By creating context around the user of the mobile device, a more rich and personal experience can be delivered. Standards make this possible (Wikipedia–GPS, 2012; Wikipedia–QR Code, 2012; Wikipedia–RFI, 2012).

Designing and Developing

Designing for the individual is great, but what best practices can be followed when undertaking the Herculean task of trying to please everyone? While it may seem daunting, the two design areas to focus on are inclusiveness and flexibility. The end result of the two is the same — to develop to everyone's needs — but the approach is different.

- *Inclusiveness*: The first focus is that of inclusion. More accurately, the focus is on making sure no one is excluded. This distinction is important because, in not excluding anyone, all possibilities must be designed for and all experiences must be equal. Section 508 of the Rehabilitation Act requires that *all* individuals have access to the same information within the United States federal government, and thus *all* information technology must be designed as such (emphasis added by authors). With this seemingly simple mandate, design is flipped on its head. An entire website (www.section508.gov) is devoted to exposing the U.S. law, providing standards and best practices, and enacting policies. The result is a design that follows a laundry list of what to do and what not to do.

- *Flexibility*: While it's extremely important to comply with Section 508, the approach of designing towards multiple sets of requirements can often produce something less usable by everyone. Ethan Marcotte found similar results when trying to tailor content to multiple devices. His solution? Responsive Web Design. "Rather than tailoring disconnected designs to each of an ever-increasing number of Web devices, we can treat them as facets of the same experience. We can design for an optimal viewing experience, but embed standards-based technologies into our designs to make them not only more flexible, but more adaptive to the media that renders them" (Marcotte, 2010).

While the design space is important, so is designing to discover content. Unless it is brought to them through a social channel, a majority of information seekers are going to use a search engine to find content. By "tagging" content, the greatest amount of search and discovery is enabled through the "Semantic Web," which "provides a common framework that allows data to be shared and reused across application, enterprise, and community boundaries" (World Wide Web Consortium [W3C], 2011). The W3C's involvement in the Semantic Web makes tagging an accepted practice for a variety of technologies, vastly increasing the chances of discovery.

There are practical ways to enable both effective searching and responsive Web design. Not surprisingly, these are enabled by a combination of best practices and Web standards. CSS and HTML, two of the aforementioned standards, are the lynchpins to successful design of both layout space and search space. For instance, media types and queries (creations of the W3C within CSS) allow the content to identify the device and react in ways that affect display size, objects and content behaviour (Marcotte, 2010). Moving forward, HTML5 offers a variety of new tags that enhance the flexibility of tagging content and is friendly towards search engine optimisation (SEO). These tags enable a variety of new technologies, including Activity Streams, Open Graph and microdata, which all can be used to drive and enhance a user's experience with the content (Dean, 2011).

Learning Standards Evolution

The harmonisation in eLearning standards, which was catalysed by the Sharable Content Object Reference Model (SCORM) of the Advanced Distributed Learning initiative (ADL), provides a stable base that, in large part, enabled the development of learning management systems. These standards now represent a widely adopted specification by an international and vendor community that will empower future eLearning efforts. Currently, the ADL initiative is working with communities of vendors and users to develop specifications, standards and best practices in an effort to support learning technology beyond the SCORM. The efforts are intended to build a future Training and Learning Architecture (or TLA). The TLA is intended to serve as a suite of specifications to further allow an ecosystem of learning technologies and content to produce environments capable not only of anywhere, anytime learning, but right-time, right-place learning in a personalised format for users (ADL, 2003). The first project of the TLA effort is known as the Experience API (ADL, 2003). The Experience API is intended to fill gaps in the SCORM model but also enable different modalities of content that were never to be supported by the SCORM. The SCORM is specifically designed

for content rendered in a Web browser. Although that approach was appropriate when the SCORM concept was conceived, it eliminates the interoperable use of newer content types such as serious games, mobile applications, virtual world simulations and augmented reality.

Work is underway to build lightweight technology to allow broad levels of tracking outside of learning management systems, to capture both digital learning experiences and even provide the potential for the capture of experiential learning. Furthermore, as data is collected, it is also *exposed* so that it can be used for assessment after the fact, statistical analysis, data mining and custom reports, and for sharing data with other systems.

Conclusion

As we look to the future, mobile technology will find new ways to connect users to the world around them and to each other. The learning opportunities that are afforded by mobile technology are just beginning to be realised as the ubiquity of devices, bandwidth, speed, size and applications are transformed by market demand.

Existing standards and practices will serve as the base for the design, delivery and tracking of mLearning content in the future. While the SCORM technology enables tracking inside the context of the LMS, the next generation of technology will provide a much lower barrier to uniformly tracking other types of digital learning experiences. As the market begins to take on these innovations, a wide array of technologies will be better able to not just deliver learning experiences but also track them. With better tracking across mobile devices for learning, current and future learning initiatives will be able to provide more personalisation and allow more experiences to be delivered and recognised via mobile devices at the time of need.

References

- About.com. (2012). Cellphones. Retrieved November 5, 2012, from <http://cellphones.about.com/>
- Advanced Distributed Learning (ADL). (2012, September 7). Introducing the Training and Learning Architecture (TLA). Retrieved November 3, 2012, from www.adlnet.gov/introducing-the-training-and-learning-architecture-tla
- Advanced Distributed Learning (ADL). (2003, January 16). Overview. Retrieved October 27, 2012, from www.adlnet.gov/overview
- Advanced Distributed Learning (ADL). (2012). Training and Learning Architecture (TLA). Retrieved November 23, 2012, from www.adlnet.gov/capabilities/tla
- Ahonen, T. (2011, January 13). Time to confirm some mobile user numbers: SMS, MMS, Mobile Internet, M-News. Retrieved October 28, 2012, from <http://communities-dominate.blogs.com/brands/2011/01/time-to-confirm-some-mobile-user-numbers-sms-mms-mobile-internet-m-news.html>

- Dean, K. (2011, November 14). SEO best practices for HTML5: Truths, half-truths & outright lies. Retrieved November 12, 2012, from <http://searchengineland.com/seo-best-practices-for-html5-truths-half-truths-outright-lies-99406>
- Lowell, S. (2001). Roman chariots, railroad tracks, milspecs, and urban legends. *Defense Standardization Program Journal*, 14–16.
- Marcotte, E. (2010, May 25). Responsive Web design. Retrieved November 7, 2012, from www.alistapart.com/articles/responsive-web-design/
- OASIS. (2012). Homepage. Retrieved November 23, 2012, from www.oasis-open.org/committees/tc_home.php?wg_abbrev=dita
- Wikipedia. (2012, June 10). Application profile. Retrieved November 7, 2012, from http://en.wikipedia.org/wiki/Application_profile
- Wikipedia. (2012, September 29). De Facto standard. Retrieved October 29, 2012, from http://en.wikipedia.org/wiki/De_facto_standard
- Wikipedia. (2012, November 23). Global Positioning System. Retrieved November 23, 2012, from <http://en.wikipedia.org/wiki/GPS>
- Wikipedia. (2012, November 21). HTML. Retrieved November 23, 2012, from <http://en.wikipedia.org/wiki/html>
- Wikipedia. (2012, November 19). IEEE 802.11. Retrieved November 23, 2012, from http://en.wikipedia.org/wiki/IEEE_802.11
- Wikipedia. (2012, November 15). QR Code. Retrieved November 23, 2012, from http://en.wikipedia.org/wiki/QR_codes
- Wikipedia. (2012, November 17). Radio-frequency identification. Retrieved November 23, 2012, from http://en.wikipedia.org/wiki/Radio_frequency_identification
- World Wide Web Consortium (W3C). (2012). W3C. Retrieved November 23, 2012, from www.w3.org/
- World Wide Web Consortium (W3C). (2011, November 7). W3C Semantic Web activity. Retrieved November 26, 2011, from www.w3.org/2001/sw/

A Pedagogical Framework for Mobile Learning: Categorising Educational Applications of Mobile Technologies into Four Types¹

Yeonjeong Park

Abstract

Instructional designers and educators recognise the potential of mobile technologies as a learning tool for students and have incorporated them into the distance learning environment. However, little research has been done to categorise the numerous examples of mobile learning in the context of distance education, and few instructional design guidelines based on a solid theoretical framework for mobile learning exist. In this paper, I compare mobile learning (mLearning) with electronic learning (eLearning) and ubiquitous learning (uLearning) and describe the technological attributes and pedagogical affordances of mobile learning presented in previous studies. I modify transactional distance theory and adopt it as a relevant theoretical framework for mobile learning in distance education. Furthermore, I attempt to position previous studies into four types of mLearning: 1) high transactional distance socialised mLearning; 2) high transactional distance individualised mLearning; 3) low transactional distance socialised mLearning; and 4) low transactional distance individualised mLearning. This paper will help instructional designers of open and distance learning to better understand the concepts of mLearning and how to more effectively incorporate mobile technologies into their teaching and learning.

Introduction

As mobile devices are becoming increasingly ubiquitous, many researchers and practitioners have incorporated the technology into their teaching and learning environments. As Keegan (2002) anticipated, “mobile learning is a harbinger of

¹ Originally published in the International Review on Research in Open and Distance Learning (IRRODL), Vol. 12, No. 5. This article is subject to Creative Commons License 2.5 (c) 2007. The original article is published at www.irrodl.org/index.php/irrodl/article/view/1000/1895. Reproduced with permission of Athabasca University – Canada’s Open University.

the future of learning” (p. 9). The applications of mobile learning (mLearning) range widely, from K–12 to higher education and corporate learning settings, from formal and informal learning to classroom learning, distance learning and field study. Despite the many forms of, and increasing services offered by, mLearning, it is still immature in terms of its technological limitations and pedagogical considerations (Traxler, 2007). And although some researchers offer a framework for theorising about mLearning with conversation theory and activity theory (Sharples, Taylor, & Vavoula, 2005; Uden, 2007; Zurita & Nussbaum, 2007), instructional designers and teachers need a solid theoretical foundation for mLearning in the context of distance education and more guidance about how to utilise emerging mobile technologies and integrate them into their teaching more effectively.

The main purpose of this chapter is to provide a better understanding of the characteristics of mLearning in the context of distance education. This is achieved by addressing three smaller goals. First, I compare mLearning with electronic learning (eLearning) and ubiquitous learning (uLearning). Based on this evolution, I then describe mLearning’s technological attributes and pedagogical affordances. Second, I adopt Moore’s transactional distance (TD) theory and modify it by adding another dimension: two distinctive forms of distance learning that I label individualised and socialised. This establishes a total of four types of mLearning. Third, I classify previous studies done on this topic according to the four types of mLearning. My conclusion is that instructional designers and individual learners will continue to incorporate mobile technologies into their teaching and learning effectively, and will pursue their educational purposes in the pedagogical framework of mLearning.

The Evolution of Mobile Learning

Mobile learning refers to the use of mobile or wireless devices for the purpose of learning while on the move. Typical examples of the devices used for mLearning include cellphones, smartphones, palm-tops, and hand-held computers. Tablet PCs, laptops and personal media players can also fall within this scope (Kukulska-Hulme & Traxler, 2005). The first generation of truly portable information has been integrated with many functions in small, portable electronic devices (Peters, 2007). Recent innovations in programme applications and social software using Web 2.0 technologies (e.g., blogs, wikis, Twitter, YouTube) or social networking sites (such as Facebook and MySpace) have made mobile devices more dynamic and pervasive and also promise more educational potential.

However, it has been widely recognised that mLearning is not just about the use of portable devices, but is also about learning across contexts (Walker, 2006). Winters (2006) reconceptualised the nature of mLearning and addressed “mediated learning through mobile technology” (p. 9). Pea and Maldonado (2006) used the term “wireless interactive learning devices,” or WILD, an acronym created at SRI International’s Center for Technology in Learning, to define technology that made it possible for learners to work at unique activities in ways that were previously impossible. Peters (2007) viewed mLearning as a useful component of the flexible learning model. In 2003, Brown summarised several definitions and terms and identified mLearning as an “extension of e-learning” (Brown, 2005, p. 299). Peters (2007) also stated that it was a subset of eLearning, a step towards making

the educational process “just in time, just enough and just for me” (Peters, 2007, p. 15). Finally, Pea and Maldonado (2006) stated that mLearning incorporates “transformative innovations for learning futures” (p. 437).

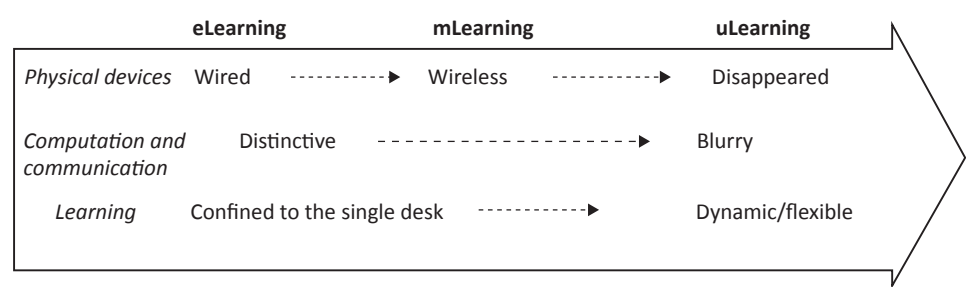
The Evolution to Ubiquitous Learning

As Weiser (1991) stated, “the most profound technologies are those that disappear” (p. 94). He was the first scholar to define ubiquitous computing as an environment where the computer is integral but embedded into the background of daily life. Applying this concept to the education field, ubiquitous learning (uLearning) involves learning in an environment where “all students have access to a variety of digital devices and services, including computers connected to the Internet and mobile computing devices, whenever and wherever they need them” (van’t Hooft, Swan, Cook, & Lin, 2007, p. 6).

In the education field, “ubiquitous computing allows us to envision a classroom in which the teacher remains focused on his or her field of expertise (e.g., math or social studies) while still utilising technology to enhance student learning” (Crowe, 2007, p. 129). Although technological tools used for uLearning can be numerous, Crowe (2007) identified hand-held computers as a key component of uLearning. Many researchers whose investigations involve hand-held and mobile devices are referring to their research as uLearning (Roschelle & Pea, 2002). As the similar terms “pervasive computing” and “context-aware computing” (Moran & Dourish, 2001, p. 87) emphasise, “smaller and lighter laptops free us from the confines of the single desk . . . the distinction between communication and computation is blurring . . . on a different scale, wall-sized displays allow us to get and interact with information in an inherently social manner.”

Figure 3.1 illustrates these conceptual shifts from eLearning to mLearning then to uLearning.

Figure 3.1: Comparisons and flow of electronic learning (eLearning), mobile learning (mLearning) and ubiquitous learning (uLearning).



Technological Attributes and Pedagogical Affordances

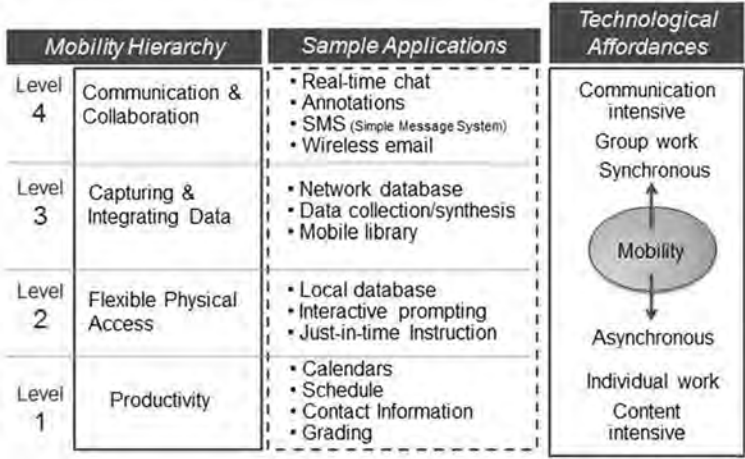
Mobile learning has unique technological attributes that provide positive pedagogical affordances. Pea and Maldonado (2006, p. 428) identified seven features of hand-held device use within schools and beyond: “portability, small screen size, computing power (immediate starting up), diverse communication networks, a broad range of applications, data synchronization across computers, and stylus input device.”

According to Klopfer and Squire (2008, p. 95), “portability, social interactivity, context, and individuality” are frequently cited affordances of mLearning, although *portability* is the most distinctive feature that distinguishes hand-held devices from other emerging technologies. That factor makes possible other technological attributes, such as individuality and interactivity.

Above all, this mobility enables uLearning in formal and informal settings by decreasing “the dependence on fixed locations for work and study, and consequently [changing] the way we work and learn” (Peters, 2007). Gay, Rieger, and Bennington (2002) developed the “mobility hierarchy,” including four levels of objectives that encourage the use of mobile computers in education settings. This hierarchy presents the contrasting attributes of mobile devices (see Figure 3.2). The focus of “productivity” (level 1) is content-intensive, whereas the focus of collaboration and communication (level 4) is communication-intensive. Level 1 aims at individual learning, and level 4 aims at collaborative learning by multiple users. Levels 2 and 3 fall into the “middle-range applications, such as personal tour guides, computer-aided instruction, database activity, mobile libraries, and electronic mail.”

As this hierarchy indicates, mobile technology has two comparable attributes. Scheduling and calendar applications are useful to increase an individual’s organisational skills and self-regulative (or self-directed) learning ability; whereas real-time chat and data-sharing applications support communication, collaboration and knowledge construction. This shows that students can consume and create information both “collectively and individually” (Koole, 2009, p. 26).

Figure 3.2: Mobility hierarchy, sample applications and technological affordances. Adopted from Gay, Rieger, and Bennington (2002).



Another unique attribute that mobile technology has is its ability to support effective face-to-face communication when students use the devices in the classroom. In contrast to using a desktop computer with several students, mobile devices mean that students do not need to crowd around one computer (Crowe, 2007; Pea & Maldonado, 2006; Roschelle & Pea, 2002). In many empirical research studies and pilot tests, participants owned the hand-held devices (even though the arrangement was temporary), and such ownership involved them more in the learning process. Above all, researchers and practitioners alike have pointed out

the advantages of the lower cost of these devices (Crowe, 2007; Pea & Maldonado, 2006; Roschelle & Pea, 2002; Shin, Norris, & Soloway, 2007).

Limitations and Considerations

Every technology has some limitations and weaknesses, and mobile devices are no exception. They have shown some usability problems. Kukulska-Hulme (2007) summarised these problems as follows:

“(1) physical attributes of mobile devices, such as small screen size, heavy weight, inadequate memory, and short battery life; (2) content and software application limitations, including a lack of built-in functions, the difficulty of adding applications, challenges in learning how to work with a mobile device, and differences between applications and circumstances of use; (3) network speed and reliability; and (4) physical environment issues such as problems with using the device outdoors, excessive screen brightness, concerns about personal security, possible radiation exposure from devices using radio frequencies, the need for rain covers in rainy or humid conditions, and so on.”

It is important to consider these issues when using mobile devices and designing the learning environment.

However, looking at how rapidly new mobile products are improving, with advanced functions and numerous applications and accessories available these days, the technical limitations of mobile devices may be a temporary concern. Also, the use of mobile technologies in education is moving from small-scale and short-term trials or pilots into sustained and blended development projects (Traxler, 2007).

The most serious issue faced by mLearning is the lack of a solid theoretical framework that can guide effective instructional design and evaluate the quality of programmes that rely significantly on mobile technologies. As Traxler (2007) pointed out, evaluation of mLearning is problematic because of its “noise” characteristic with “personal, contextual, and situated” attributes (p. 10). Several attempts to conceptualise mLearning have been made since the emergence of mobile and wireless technologies. Traxler (2007) provided six categories by reviewing existing trials and pilot case studies in the public domain:

- technology-driven mLearning
- miniature but portable eLearning
- connected classroom learning
- informal, personalised, situated mLearning
- mobile training/performance support
- remote/rural/development mLearning

Koole (2009) developed a framework for the rational analysis of mobile education (or FRAME model), which presents three aspects of mLearning: the device, the learner and the social environment. This model also highlights the intersections of each aspect (device usability, social technology and interaction learning) and

the primary intersection of the three aspects (mLearning process) in a Venn diagram. What makes this FRAME model useful are the criteria and examples of each aspect and interaction and the checklist that might help educators plan and design mLearning environments.

The definitions, technological attributes and existing frameworks of mLearning introduced above can help readers understand mLearning and how it is relevant to the future of teaching and learning with mobile technologies. However, previous studies and efforts suffer from the lack of a pedagogical framework. A number of the applications of mobile technologies in learning have shown a few links to established pedagogical theory. There is a need for the many different directions and unique applications to be logically categorised within the context of distance education. By categorising educational applications with mobile technologies and positioning them in a logical framework, one can better understand the current status of mLearning and come up with comprehensive design guidelines for its future use. The transactional distance theory provides a useful framework based on sound theoretical and pedagogical foundations that can define the role of mLearning in the context of distance education.

Transactional Distance Theory

Transactional distance theory is an educational theory that defines the critical concepts of distance learning. It presents a definition of distance education that implies the separation of teachers and learners (Moore, 2007). Since its first appearance in publications (Moore, 1972, 1973), this theory has influenced numerous researchers and practices. Many scholars praise it as a classical and all-encompassing theory of distance learning (Gokool-Ramdoo, 2008; Saba, 2005) and view it as a major contribution to the field of distance education.

Transactional distance theory is defined by the fact that distance is considered not only as geographic separation but also (and more importantly) as a pedagogical concept (Moore, 1997). As a result, the theory enables the inclusion of both types of education, that is, “a program in which the sole or principal form of communication is through technology” and where “technology-mediated communication is ancillary to the classroom” (Moore 2007, p. 91). This is especially important for mLearning because mobile devices sometimes enter the school setting (Tatar, Roschelle, Vabey, & Pennuel, September, 2003) as an ancillary element, but mostly they extend beyond the classroom to non-traditional, informal, and non-institutional settings. The inclusive nature of transactional distance theory and its applicability and flexibility illustrate its important contribution to the framework for mLearning.

This theory was derived from the concept of “trans-action,” which is considered by many scholars to be the most evolved level of inquiry, compared with self-action and inter-action (Dewey & Bentley, 1946), and “the interplay among the environment, the individuals and the patterns of behaviors in a situation” (Boyd & Apps, 1980, p. 5). Thus, *transactional distance* is defined as the “interplay of teachers and learners in environments that have the special characteristics of their being spatially separate from one another” (Moore, 2007, p. 91). In short, transactional distance is the extent of *psychological* separation between the learner and the instructor (Moore, 2007; Shearer, 2007).

The transactional distance is controlled and managed by three interrelated factors: 1) the programme’s structure; 2) the dialogue that the teacher and learners exchange; and 3) the learners’ autonomy. Moore (2007) explained that these three factors were derived from the analysis of: 1) *curricula* of the distance learning programme; 2) *communication* between teachers and learners; and 3) *the role of learners* in deciding what, how and how much to learn. Table 3.1 summarises the three elements along with the unit of analysis, the focus, related questions, constructs, and degrees or ranges. However, the most appealing component of Moore’s transactional distance theory is the *inverse* relationship between structure and dialogue. That is, as structure increases, transactional distance increases, but as dialogue increases, transactional distance decreases. This hypothesis has been verified in several studies (Saba, 1988; Saba & Shearer, 1994). The theory becomes more complex by adding the third variable, learner autonomy, because it is unclear whether this represents the learner’s personal autonomy or the autonomy associated with learning materials. Nevertheless, the theory explains that as transactional distance increases, so does learner autonomy.

Moore (1997) illustrated four types based on the presence or absence of dialogue (D) and structure (S), ranging from –D–S to –D+S or +D–S to +D+S. Considering the combinations of variables that are relative and continuous rather than absolute or dichotomous, there could well be infinite types of learning and teaching. Furthermore, for each type, learner autonomy can vary widely from complete autonomy (AAA) to no freedom (NNN), even though the right balance is necessary for successful results.

Table 3.1: The three elements of original transactional distance theory

	Structure	Dialogue	Learner autonomy
Unit of analysis	Curricula of distance learning programme ^a	Communication between instructor and learner ^a	Learner’s role ^a
Definition	A measure of an educational programme’s responsiveness to learners’ individual needs or preferences ^c	Exchanges of words and other symbols between instructor and learner that occurs after a course is designed, for improved understanding and knowledge construction ^{a,c}	Learners’ degree of freedom and self-management ability in regard to determination of learning goal, process and evaluation ^a
Focus	Rigidity and flexibility of structure ^a	Extent and nature of dialogue ^a	Dimensions and ranges of autonomy ^a
Related question	How rigid or flexible is the distance learning programme?	How many types and what quality of communication do the instructor and students generate?	How much and what kind of autonomy does the program give to learners?
Constructs	Sequence, contents, theme, objectives, outcomes, teaching and assessment strategy ^b	Direct, indirect, active and passive speech ^c Academic, collaborative and interpersonal interaction ^e	Goals, execution and evaluation

	Structure	Dialogue	Learner autonomy
Degrees or ranges	<i>Sequence:</i> From tightly controlled to loosely controlled <i>Contents:</i> From pre-determined to post-determined <i>Strategy:</i> From rigidly set to flexibly changeable From high transactional distance to low transactional distance. ^b Examples: – D–S: low dialogue and low structure (e.g., textbook) –D+S or +S–D: low dialogue and high structure (e.g., radio programme, programmed text) +D+S or +D+S: high dialogue and high structure (e.g., correspondence, computer-assisted instruction) +D–S: high dialogue and low structure (e.g., tutorial, teleconference)	<i>Quantity:</i> From frequent communication to rare communication between instructor and learner <i>Quality:</i> From deep to superficial interaction From factual (information share) to reflective dialogue (knowledge share) ^f	From AAA to NNN ^{a,b} AAA: full autonomy AAN: autonomy in setting goals and execution (external certification programme) ANA: autonomy in setting goals and evaluation (programmed learning) ANN: autonomy only in setting goals (uncommon) NAA: autonomy in execution and evaluation (uncommon) NNA: autonomy only in evaluation (most rare) NAN: autonomy only in execution (the most common situation) NNN: no autonomy
Relation with transitional distance	As structure increases, transactional distance increases ^a	As dialogue increases, transactional distance decreases ^a	As transactional distance increases, learner autonomy increases ^a

^aMoore (2007)

^bMoore (1997)

^cSaba and Shearer (1994)

^dShearer (2007)

^eJung (2001)

^fSahin (2008)

Another interesting aspect of this theory is the influence of communication media on transactional distance. In Moore’s examples (2007), a recorded television or radio programme is considered to have a high degree of structure because the programme would not be changed to meet individual learners’ needs, resulting in relatively high transactional distance; whereas an audio or video teleconference between an instructor and a single student would involve a high degree of dialogue because the instructor can change the programme’s structure based on individual learners’ responses, resulting in relatively low transactional distance. Considering the attributes of today’s advanced mobile technologies that support both individualised application and networked communication, synchronous and asynchronous communication, and text-based communication and videoconferencing, the transactional distance is influenced not only by a single communication medium but also by diverse learning contexts, including multiple communication methods and channels.

Benson and Samarawickrema (2009) positioned those different eLearning contexts in a two-by-two matrix of dialogue and structure and demonstrated the relative levels of dialogue, structure and autonomy. They introduced several cases, including: 1) on-campus, classroom-enhanced (–D–S–A); 2) on-campus, blended (–D+S–A); 3) workplace-based, blended (+D–S+A); 4) on-campus, multiple campuses, wholly online (+D–S+A); 5) off-campus, transactional, wholly online (+D+S–A); and 6) off-campus, transactional, partially online (+D+S+A).

Although the cases were derived from two university situations, the matrix presents the categorised types of current eLearning contexts. This study points out that “transactional distance is likely to be high for students who are less familiar with learning in Web 2.0 environments” (Benson & Samarawickrema, 2009, p. 17). As a result, “teachers need to design for high levels of dialogue and structure surrounding the Web 2.0 environment in order to support students.” This study concludes that the understanding of transactional distance theory is still useful and important for analysing and designing such diverse contexts of eLearning.

Kang and Gyorke (2008, p. 203) also state that the recent developments of social software and communication technologies require a more “seamlessly synchronized” theory. They compare transactional distance theory with cultural-historical activity theory (CHAT), which provides important insights about the social aspects of human activity. They point out that both theories identify “mediation” but each explains it differently. In transactional distance theory, the physical device mediates communication to overcome the separation of teacher and student. In CHAT, artifacts — including language, technology, tools and signs — mediate all of the social aspects of human activity. As a result, “in contrast to CHAT’s view of communal individual, transactional distance isolates learners from their multi-society contexts.” The study concludes that the major variables in the theory are “contradictory and complementary” (Kang & Gyorke, 2008, p. 211). Such a perspective is consistent with previous critiques: the variables’ tautology is such that “as understanding increases, misunderstanding decreases” (Gorsky & Caspi, 2005, p. 8), but inconsistent use of terms and ambiguous relations among variables allow different people to interpret the theory differently (Garrison, 2000).

The majority of interpretations of, and previous studies about, transactional distance theory commonly indicate its usefulness in understanding distance learning and evaluate its usefulness as a pedagogical and philosophical framework. However, several issues raised from previous studies include (1) problems with terminology, (2) divergent views about relations between variables, and (3) an inability to explain the individual’s social characteristics. Thus, several researchers have addressed the need for a more refined theory that addresses these issues.

A Pedagogical Framework of Mobile Learning

In this paper, I do not propose a newer version of the theory, but attempt to adapt it in order to review a variety of educational applications of mobile technologies and categorise them into several types to gain a better understanding of current mLearning. While this paper follows the original concepts, I wish to make my own perspective of this theory clear and consistent.

Many researchers have interpreted transactional distance theory in different ways and the various interpretations and operational definitions have influenced its evolution. Garrison (2000, p. 9) pointed out earlier that “understanding transactional distance very much depends upon whether we are discussing a two-by-two matrix, a single continuum, or distinct clusters.” For this paper, I choose to regard transactional distance as a single continuum from high transactional distance to low transactional distance, because viewing it as a two-by-two

matrix or distinct clusters makes the model more confusing due to the complex interrelations of variables. Three variables (structure, dialogue and autonomy) control transactional distance (Moore, 1997, 2007), but as other scholars have pointed out (Garrison, 2000; Gorsky & Caspi, 2005; Saba & Shearer, 1994), the interrelationships are inverse or orthogonal between structure and dialogue and overlapping or hierarchical between structure and autonomy (Gorsky & Caspi, 2005).

Such viewpoints about variable interrelationships in TD theory might be valid. However, in this case, complex variables and their relationships with each other determine transactional distance. What we need to determine is how to define transactional distance as a single continuum. For the purpose of this paper, I adhere to the original and official definition of the theory: “a psychological and communications space to be crossed, a space of potential misunderstanding between the inputs of instructor and those of the learner” (Moore, 1997, p. 22).

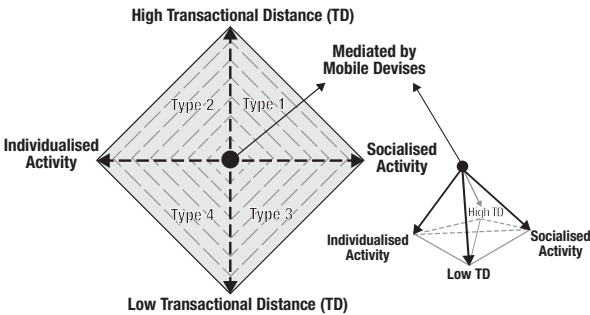
Nevertheless, when the transactional distance is defined as a psychological gap between instructor and learner, it still contradicts definitions of structure and dialogue. Because of the recent developments of emerging communication technologies, structures of learning are built not only by the instructor or instructional designer but also by collective learners; and dialogue is also formed not only between the instructor and learners, but also among the learners themselves. Working in wikis is an example of how learners build structure through dialogue (Benson & Samarawickrema, 2009). Regarding dual types of dialogue, Moore (1997) already mentioned that a new form of dialogue called “inter-learner dialogue” can make knowledge creation possible for distance learners. Structure and dialogue, previously defined as being under the instructor’s control, have evolved into something that learners can also form. Because of this, every definition regarding transactional distance must now include the interaction among learners, which contradicts the original definition of transactional distance as a communicational gap between instructor and learner. To resolve this contradiction, it is necessary to define the dialogue and structure that influence transactional distance as only the interactions that take place between the instructor and learners, and to exclude the interactions among learners. Any kind of dialogue and structure built by learners alone should be discussed in a different dimension. Such a dimension is discussed below.

This new dimension connotes “individual versus collective (or social)” activities by considering the importance of the social aspects of learning as well as of newer forms of social technologies. This idea was formed by the influence of cultural-historical activity theory that Kang and Gyorke (2008) compared with transactional distance theory. However, I move beyond comparing each theory and synthesise them to explain some phenomena more effectively. A number of researchers (Frohberg, Goth, & Schwabe, 2009; Sharples, Taylor, & Vavoula, 2007; Taylor, Sharples, O’Malley, Vavoula, & Waycott, 2006; Uden, 2007; Zurita & Nussbaum, 2007) have used activity theory as a theoretical framework for mLearning.

Some researchers recognise activity theory as a powerful framework for designing constructivist learning environments and student-centred learning environments (Jonassen, 2000; Jonassen & Rohrer-Murphy, 1999). However, certain limitations and unsolved problems in activity theory have been raised. Barab, Evans, and

Baek (1996, p. 209) pointed out that “life tends not to compartmentalize itself or act in ways that are always wholly consistent with our theoretical assumptions.” They suggested researchers move from isolated to complementary theoretical perspectives. Although I do not describe the details of activity theory in this chapter (for more information, see: Engeström, 1987; Leont’ev, 1978; Vygotsky, 1978), I do use several elements of it to modify transactional distance theory, adding a dimension and creating a pedagogical framework for mLearning (illustrated in Figure 3.3).

Figure 3.3: Four types of mobile learning: a pedagogical framework.



- First, *activity* is conceived as a unit of analysis. Since transactional distance theory considers a course or programme to include several lessons (Moore, 2007), this can make it difficult to decide the transactional distance for the course as a whole. For example, the presentation of information is likely highly structured, while questions for discussion require a high-dialogue process, but both of these activities are typically course components. As a result, a course including several activities with different degrees of transactional distance cannot be categorised simply as either high or low transactional distance. Thus, by confining the unit of analysis to “activity,” it is easier to determine to what extent transactional distance can exist because the activity is a “minimal meaningful context for individual actions” (Kuutti, 1996, p. 26).
- Second, individualised and socialised activities are *mediated* by communication technology, which is one kind of cultural-historical artifact in activity theory. As Kang and Gyorke (2008) point out, both transactional distance theory and activity theory consider mediation to be important. Thus, with “mediation” at the centre of the framework, individualised activity at one extreme indicates a form where a learner is isolated from communicating with other students, and socialised activity at the other extreme indicates a form where students work together, share their ideas and construct knowledge. At the same time, activities are mediated by the rule that can be either highly structured with fewer dialogic negotiations (high transactional distance) or loosely structured with more free dialogic negotiations (low transactional distance). As mentioned above, mLearning is “mediated learning by mobile technologies” (Winters, 2006) and the mobile technologies uniquely support students’ learning both collectively and individually (Koole, 2009). In placing high or low transactional distance on the *y* axis and individualised or socialised activity on the *x* axis, the framework generates four types of mLearning activities.

- Third, the dualism of *individual* versus *collective* (or social) is a dichotomy, but it is also something to be connected and balanced. Activity theory has attempted to transcend the issue of dualism in such pairs as individual-society, subjectivity-objectivity, agency-structure and psychological-social (Roth & Lee, 2007; Watson & Coulter, 2008). However, according to Garrison (2001), Leont'ev's activity theory (1978) drew close to Dewey's theory of transactional co-ordination, but Dewey pushed his functionalism beyond describing "inter-actions" to a theory of "trans-actions." There are similarities and differences between the approach of activity theory and the approach of transactional distance theory derived from Dewey's work. Activity theory is an analytic framework for understanding an individual's (subject) actions on learning material (objects) mediated through artifacts, interacting with a community, moderated by a set of rules and distributed by a division of labour (Engeström, 1991). It forms a part of the basis for transactional distance theory, which is a framework for understanding the relations of key variables (structure, dialogue and autonomy) in the context of distance learning. Although a number of important concepts from activity theory are simplified in Figure 3.3, a dimension indicating the range of individualised to socialised activity can be a useful lens for reviewing diverse mLearning activities. Above all, the distinction between individual and socialised activity is a generally understood and accepted categorisation. For example, Keegan (2002) stated that distance learning has two forms, individual and group learning.

Educational Applications of Mobile Technologies

The major purpose here is to review and classify a variety of educational applications with mobile technologies. For this purpose, a conceptual and pedagogical framework was generated based on high versus low transactional distance and individualised versus socialised activity. As shown in Figure 3.3, the four types of mLearning generated in the context of distance education include (1) high transactional distance socialised mLearning, (2) high transactional distance individualised mLearning, (3) low transactional distance socialised mLearning, and (4) low transactional distance individualised mLearning.

Type 1: High Transactional Distance and Socialised Mobile Learning Activity (HS)

An mLearning activity is classified as this type when: 1) the learners have more psychological and communication space with their instructor or institutional support; 2) the learners are involved in group learning or projects where they communicate, negotiate and collaborate with each other; 3) learning materials or the rules of activity are delivered from the pre-determined programme through mobile devices; and 4) transactions mainly occur among learners, and the instructor or teacher has minimal involvement in facilitating the group activity. This type might replace the traditional technology-mediated classroom group activity where students in a group or pair conduct given tasks or assignments.

NetCalc, for instance, is a hand-held version of *SimCalc*, an application designed to help middle-school students learn mathematics of change and variation (Vahey, Roschelle, & Tatar, 2007; Vahey, Tatar, & Roschelle, 2004). Three innovations were considered during the development of the *SimCalc* project: “restructuring the subject matter, grounding mathematical experience in students’ existing understanding, and providing dynamic representations” (Vahey et al., 2004, p. 554). *NetCalc* allowed students to play games in pairs and practise very specific mathematical concepts. For example, in the game *Match-My-Graph*, “one student (the grapher) creates a function that is hidden from the other (the matcher). . . . The matcher makes and beams an initial guess of the function, and receives a verbal clue from the grapher” (Vahey et al., 2004, p. 555). While this game involves learning the characteristics of position graphs and velocity graphs and how to translate between each kind, the mobile activity supported both “communication capabilities and representational infrastructures of handheld computers.”

The *MCSCCL* system is another example of this type (Cortez, Nussbaum, Santelices, Rodriguez, & Zurita, 2004). This system was developed to teach high-school students in a physics classroom. It was designed and implemented for students in groups to answer a set of multiple-choice questions transmitted through mobile devices. In this activity, students have to debate how to answer the questions and must come to an agreement on the choices that the group selects. In this process, they modify their existing knowledge schemes and construct new knowledge by collaborating with other students. The teacher helps to set up and transmit the questions to students before the collaborative activity, and collects the students’ work afterwards.

The *Math MCSCCL* project uses activity theory as a conceptual framework (Zurita & Nussbaum, 2007). An activity was developed to enable Grade 2 students to practise addition, subtraction and multiplication in a group. In this activity, students with a certain number of objects (such as bananas, apples and oranges) on their mobile device have to reach the target quantity for each object by exchanging them with other students. Individual students keep track of the quantities of each object by performing arithmetic operations and search for other students to exchange objects with. They have to talk, negotiate and collaborate to achieve the goal of the game.

The examples above were selected as high transactional distance because these activities all require a highly structured programme. Questions for activities or the rules of the game are determined prior to the activity. Although the content area in the examples was science or mathematics, these activities nonetheless required and aimed to build social interaction, negotiation, and collaboration skills among group members. In developing this type of activity, instructors and instructional designers may need to give special attention and effort to: 1) the design of the mobile application; and 2) the set-up of social interaction, such as defining the rules of the game and the roles of players. Considerations on both the computational (software) aspect and the functionality (hardware) aspect of mobile devices might be critical to successful implementation of the activity.

Type 2: *High Transactional Distance and Individualised Mobile Learning Activity (HI)*

Mobile learning activities are classified as type 2 when: 1) the individual learners have more psychological and communication space with the instructor or instructional support; 2) the individual learners receive tightly structured and well-organised content and resources (e.g., recorded lectures, readings) through mobile devices; 3) the individual learners receive the content and control their learning process in order to master it; and 4) the interactions occur mainly between the individual learner and the content. This type demonstrates an extension of eLearning that allows greater flexibility and portability. Individual learners fit this flexible learning into their mobile lifestyle. This type is mostly influenced by the context regarding when and where to learn. It also includes mLearning that makes access to the educational system possible for students in rural areas.

The off-campus postgraduate development programme of the Australian National University (Beckmann, 2010) is an example of this type, implemented both online and on mobile modes of distance learning. For the MAAPD (Master of Applied Anthropology and Participatory Development) programme, students who are enrolled in distance learning are offered downloadable resources (e.g., readings, audio or video lectures, presentation slideshows) and opportunities to interact with others in online discussion. The major role of lecturers is to establish the online discussion and upload podcasts and vodcasts to the learning management system (LMS). Authoring tools such as Camtasia studio or Wimba Create were used to build these media-rich resources. Although learning activities and tasks based on a constructivist perspective were implemented and demonstrated, comments on this project describe the benefits of mobility. The responses of participants included these statements: “the ability to download lectures onto my iPod while I was travelling was really useful,” and “I downloaded lectures (audio version) . . . played them over my stereo via my laptop while I cooked dinner at home . . . this was invaluable as I had a very demanding job” (Beckmann, 2010, p. 169). This feedback shows that mobile devices are used to make it possible for individual workers with busy schedules to learn at their preferred places and times.

Mobile learning for students in remote sites or underserved areas is another typical example of this type. Vyas, Albright, Walker, Zachariah, and Lee (2010) applied mobile technology to clinical training at remote secondary hospital sites in India. Synergy was achieved with the use of the TUSK knowledge database through the partnership of the Christian Medical College (CMC) in India and Tufts University School of Medicine in the U.S. This is an mLearning system that is part of campus-based eLearning supports in CMC. It is designed to enable students to access a knowledge repository through their own mobile phones and to fulfil their learning needs using other mobile applications.

As another example, Kim (2009) shared action research to design an mLearning project for underserved migrant indigenous children in Latin America. In this project, mLearning was used to develop the literacy of migrant children who live in villages far away from the centres of towns, where a formal education is not easily accessible. Through early prototypes of mobile devices, an *Alfabeto* lesson is delivered to children. The lesson displays alphabet letters and sample

words starting with each letter, delivers a voice recording of letters and words, and provides short stories with sequenced animations and corresponding texts. This project shows how the portability and multimedia features of mobile technology, as well as its low cost, can help disadvantaged populations, including illiterate children and their families who live far away from public services such as education or healthcare.

Mobile-assisted language learning (MALL) is a notable example of type 2. MALL is distinguished from computer-assisted language learning (CALL) because it focuses on the “continuity or spontaneity of access and interaction across different contexts of use” (Kukulska-Hulme, 2009, p. 162). As an example of such a function of “context-awareness,” Chen and Li (2010) applied a wireless positioning technique to a programme for teaching English vocabulary. Individual learners discover and learn new vocabulary by logging in to a personalised context-aware ubiquitous learning system (PCULS). The system retrieves learners’ personal portfolios, including their leisure time and English level, and automatically senses their location. Appropriate vocabulary material is then suggested from the database, based on the learner’s portfolio and location context. In spite of technical problems (e.g., access difficulties), there is a relatively high success rate in detecting the learner’s location and facilitating enhanced learning performance. Learner satisfaction in the experiment holds promise for a future seamless ubiquitous English learning environment.

Although it was not possible to find a case in the scholarly literature in which the learners simply accessed open resources (e.g., YouTube) or online tutorials through mobile devices, such a case could also fall into this type because individual learners engage in self-directed learning as they search for information and gain knowledge without the intervention of a teacher or instructor. The examples introduced above represent relatively high transactional distance because the instructor or teacher played a minimal role in helping individual learners take control of the learning process. Individual learners in this type decided where and when to learn and personalised their learning environments. In developing this type of mLearning activity, instructional designers or institutional distance learning support staff should pay special attention to the creation and management of a knowledge database, including well-organised learning materials such as lecture (audio or video) files, reading materials and vocabulary databases. The most important considerations might be accessibility and technical connection problems. The studies introduced above commonly reported such technical issues caused by different learner environments.

Type 3: Low Transactional Distance and *Socialised* Mobile Learning Activity (LS)

In this type, individual learners interact both with the instructor and other learners as they use mobile devices. They have less psychological and communication space with the instructor and loosely structured instruction, but they work together in a group as they solve the given problem and try to achieve a common goal. They also engage in social interaction, negotiation, and frequent communication naturally. This type demonstrates the most advanced forms in terms of the versatility of mobile devices and learners’ social interactions.

Klopfer, Squire, and Jenkins (2002) developed, and Klopfer and Squire (2008) examined, *Environmental Detectives*, a simulation platform designed as a game for mobile devices. Students play the role of environmental engineers and are given a scenario in which the spread of a toxin is simulated on a location-aware Pocket PC equipped with a GPS (geographical positioning system). The Pocket PC allowed students to investigate a toxic spill by collecting samples to test for chemicals in the groundwater and required them to respond to different variables programmed by the teacher. Many students indicated that these types of collaborative activities helped them evaluate diverse choices, motivated them and transformed their perceptions of learning.

An audio-based learning forum project (Chang, 2010) enabled learners to participate in an asynchronous learning forum on mobile devices, which replaced the text-based discussion online forum. Since multimedia message services (MMS), an evolved form of short message services (SMS), can send not only text but also graphics, video and audio clips, this project used audio-based input to post discussion articles in an audio file format. Learners can download audio files recorded by their peer learners and listen while on the move. Although there are some disadvantages, such as background noise, the inability to search through a message and difficulty in reviewing the recorded audio files, hands-free operation and the flexibility of learning are great advantages. In order to increase the participation in discussion and collaborative learning, a team game tournament (TGT) was integrated into this activity. Heterogeneous groups consisting of three members were initially formed and then regrouped for the tournament based on their performance in the first round.

Relatively few studies of this type exist. A common characteristic in both examples is that concrete contents or a specific learning outcome are not defined prior to someone starting the activity. Also, mobile devices are used for multiple functions as an investigation tool, a communication tool, and a simulation and game tool. When developing this type of learning, instructional designers and instructors should promote active participation and allow students to have many social experiences. The most important consideration is to develop a meaningful collaborative task or a complex situation so that higher-order thinking, negotiation, evaluation, reflection, debate, competition and scaffolding can naturally occur.

Type 4: Low Transactional Distance and Individualised Mobile Learning Activity (LI)

This last type of mobile activity refers to less psychological and communication space between instructor and learner and loosely structured and undefined learning content. On this basis, individual learners can interact directly with the instructor, and the instructor leads and controls the learning in an effort to meet individual learners' needs while maintaining their independence. This type shows characteristics unique to mLearning that support blended or hybrid learning.

A large blended classroom project in China (Shen, Wang, Gao, Novak, & Tang, 2009; Wang, Shen, Novak, & Pan, 2009) is a similar approach to type 2 as it pursues anytime, anywhere learning. However, this project aims to increase

Chinese students' class interactivity using technical intervention. In the upper-level English class, a mobile phone broadcasting system, classroom management system, and a networking system are all established for distance learners not only to download course materials but also to connect with the class in real time, while the instructor provides lectures using a computer, a projector, whiteboards and other tools for instruction. Since this type of learning is a kind of large-scale lecture, frequent dialogue between instructor and students is difficult (that is why it is not categorised as type 2, high transactional distance). However, students can send messages and ask questions of the instructor using their mobile phones, and the instructor can respond to them with an oral explanation in real time. This function, enabled by mobile technology, supports a reduction of transactional distance.

Mobile butterfly-watching and bird-watching learning system projects (Chen, Kao, & Sheu, 2003; Chen, Kao, Yu, & Sheu, 2004) support outdoor mLearning activities. In these projects, mobile devices are used by independent learners to access a bird or butterfly knowledge database to match the butterfly or bird that they observe and photograph. In this system, mobile devices make field trips for science learning much simpler because learners do not need to carry a notebook for observation and can find the necessary information more easily and quickly. They take pictures with the digital camera that is built into the mobile device, store their notes in it and send them to the server using a wireless Internet connection. While the teacher encourages students to observe diverse objects and assigns questions to make sure they are learning, students engage mostly in self-directed and independent learning, and the mobile devices support the learning process through scaffolding.

Because a teacher mainly controls and leads the activities in this type, and learning contents and processes are structured as individual students reach the end of the activity and the class, these examples are considered low transactional distance. Also the flexibility and portability afforded by the mobile devices support individualised learning. To prepare for this type of learning, instructional designers and teachers should pay attention to the student environment from a distance both in the classroom and on field trips and should provide appropriate supports as students ask questions and complete the given tasks or assignments.

Conclusion

In this chapter, I introduced a definition of mLearning, outlined its characteristics and compared it with eLearning. Despite the great potential mLearning has and the innovative development of mobile technologies, a theoretical framework in which to review diverse mLearning projects in the context of distance learning has been lacking. The framework for this analysis was adopted from transactional distance theory and modified by adding a new dimension to reflect the characteristics of mobile technologies that support both individual and social aspects of learning. Previous studies dealing with mLearning were reviewed and categorised into four types based on transactional distance and individualised versus socialised learning.

The literature reviewed in this study was limited to a few examples from the rapidly growing body of research on mLearning. Although a small number of

case studies have been introduced here, there are several other exemplary projects that can be classified within the four types of mLearning activities. I developed this classification scheme hoping to help instructional designers and instructors to design and implement mLearning more effectively. Reviewing mobile projects within the framework of the four types also confirmed that mobile devices uniquely support seamless movement and switch (Looi et al., 2008; Vahey et al., 2007) between individualised (personalised) and socialised learning and between high transactional distance and low transactional distance.

References

- Barab, S. A., Evans, M. A., & Baek, E.-O. (1996). Activity theory as a lens for characterizing the participatory unit. In D. H. Jonaassen (Ed.), *Handbook of research for educational communication and technology* (2nd ed., pp. 199–211). New York: Simon & Schuster Macmillan.
- Beckmann, E. A. (2010). Learners on the move: Mobile modalities in development studies. *Distance Education*, 31(2), 159–173.
- Benson, R., & Samarawickrema, G. (2009). Addressing the context of e-learning: Using transactional distance theory to inform design. *Distance Education*, 30(1), 5–21.
- Boyd, R. D., & Apps, J. W. (1980). *Redefining the discipline of adult education*. San Francisco: Jossey-Bass.
- Brown, T. H. (2005). Towards a model for m-learning in Africa. *International Journal of E-Learning*, 4(3), 299–315.
- Chang, C.-K. (2010). Acceptability of an asynchronous learning forum on mobile devices. *Behaviour and Information Technology*, 29(1), 23–33.
- Chen, C.-M., & Li, Y.-L. (2010). Personalised context-aware ubiquitous learning system for supporting effective English vocabulary learning. *Interactive Learning Environments*, 18(4), 341–364.
- Chen, Y.-S., Kao, T.-C., & Sheu, J.-P. (2003). A mobile learning system for scaffolding bird-watching learning. *Journal of Computer Assisted Learning*, 19, 347–359.
- Chen, Y.-S., Kao, T.-C., Yu, G.-J., & Sheu, J.-P. (2004). *A mobile butterfly-watching learning system for supporting independent learning*. Paper presented at the 2nd IEEE International Workshop on Wireless and Mobile Technologies in Education, JungLi, Taiwan.
- Cortez, C., Nussbaum, M., Santelices, P., Rodriguez, P., & Zurita, G. (2004). *Teaching science with mobile computer supported collaborative learning (MCSCCL)*. Paper presented at the 2nd IEEE International Workshop on Wireless and Mobile Technologies in Education.
- Crowe, A. R. (2007). Learning to teach with mobile technology: A teacher educator's journey. In M. van't Hooft & K. Swan (Eds.), *Ubiquitous computing in education* (pp. 127–144). Mahwah, NJ: Lawrence Erlbaum Associates.

- Dewey, J., & Bentley, A. F. (1946). Interaction and transaction. *The Journal of Philosophy*, 43(19), 505–517.
- Engeström, Y. (1987). *Learning by expanding*. Helsinki: Orienta-Konsultit.
- Engeström, Y. (1991). Activity theory and individual and social transformation. *Multidisciplinary Newsletter for Activity Theory*, 7(8), 14–15.
- Frohberg, D., Goth, C., & Schwabe, G. (2009). Mobile learning projects: A critical analysis of the state of the art. *Journal of Computer Assisted Learning*, 25, 307–331.
- Garrison, R. (2000). Theoretical challenges for distance education in the 21st century: A shift from structural to transactional issues. *International Review of Research in Open and Distance Learning*, 1(1), 1–17.
- Gay, G., Rieger, R., & Bennington, T. (2002). Using mobile computing to enhance field study. In T. Koschmann, R. Hall, & N. Miyake (Eds.), *CSCL2: Carrying forward the conversation* (pp. 507–528). Mahwah, NJ: Lawrence Erlbaum Associates.
- Gokool-Ramdoo, S. (2008). Beyond the theoretical impasse: Extending the applications of transactional distance theory. *The International Review of Research in Open and Distance Learning*, 9(3), 1–17.
- Gorsky, P., & Caspi, A. (2005). A critical analysis of transactional distance theory. *The Quarterly Review of Distance Education*, 6(1), 1–11.
- Jonassen, D. (2000). Revisiting activity theory as a framework for designing student-centered learning environments. In D. H. Jonassen & S. M. Land (Eds.), *Theoretical foundations of learning environments* (pp. 89–121). Mahwah, NJ: Lawrence Erlbaum Associates, Publishers.
- Jonassen, D., & Rohrer-Murphy, L. (1999). Activity theory as a framework for designing constructivist learning environments. *Educational Technology Research and Development*, 47(1), 61–79.
- Jung, I. (2001). Building a theoretical framework of web-based instruction in the context of distance education. *British Journal of Educational Technology*, 32(5), 535–534.
- Kang, H., & Gyorke, A. S. (2008). Rethinking distance learning activities: A comparison of transactional distance theory and activity theory. *Open Learning*, 23(3), 203–214.
- Keegan, D. (2002). *The future of learning: From eLearning to mLearning*. ZIFF papière 119. Retrieved from ERIC ED472435 database. Available from www.fernuni-hagen.de/ZIFF
- Kim, P. H. (2009). Action research approach on mobile learning design for the underserved. *Educational Technology Research and Development*, 57, 415–435.
- Klopfer, E., Squire, J., & Jenkins, H. (2002). *Environmental detectives: PDAs as a window into a virtual simulated world*. Paper presented at the IEEE International Workshop on Wireless and Mobile Technologies in Education (WMTE'02), Los Alamitos, CA.

- Klopfer, E., & Squire, K. (2008). Environmental detectives: The development of an augmented reality platform for environmental simulations. *Educational Technology Research and Development*, 56(2), 203–228.
- Koole, M. L. (2009). A model for framing mobile learning. In M. Ally (Ed.), *Mobile learning: Transforming the delivery of education and training* (pp. 25–47). Edmonton, AB: Athabasca University Press.
- Kukulska-Hulme, A. (2007). Mobile usability in educational context: What have we learnt? *International Review of Research in Open and Distance Learning*, 8(2), 1–16.
- Kukulska-Hulme, A. (2009). Will mobile learning change language learning? *ReCALL*, 21(2), 157–165.
- Kukulska-Hulme, A., & Traxler, J. (2005). *Mobile learning: A handbook for educators and trainers*. London: Routledge.
- Kuutti, K. (1996). Activity theory as a potential framework for human-computer interaction research. In B. A. Nardi (Ed.), *Context and consciousness: Activity theory and human-computer interaction* (pp. 17–44). Cambridge, MA: The MIT Press.
- Leont'ev, A. N. (1978). *Activity, consciousness, and personality* (M. J. Hall, Trans.). Englewood Cliffs, NJ: Prentice-Hall, Inc.
- Looi, C.-K., Seow, P., Zhang, B., So, H.-J., Chen, W., & Wong, L.-H. (2008). Leveraging mobile technology for sustainable seamless learning: A research agenda. *British Journal of Educational Technology*, 41(2), 154–169.
- Moore, M. G. (1972). Learner autonomy: The second dimension of independent learning. *Convergence*, 5(2), 76–88.
- Moore, M. G. (1973). Toward a theory of independent learning and teaching. *The Journal of Higher Education*, 44(9), 661–679.
- Moore, M. G. (1997). Theory of transactional distance. In D. Keegan (Ed.), *Theoretical principles of distance education* (pp. 22–38). New York: Routledge Studies in Distance Education.
- Moore, M. G. (2007). The theory of transactional distance. In M. G. Moore (Ed.), *Handbook of distance education* (pp. 89–105). Mahwah, NJ: Lawrence Erlbaum Associates.
- Moran, T. P., & Dourish, P. (2001). Introduction to this special issue on context aware computing. *Human-Computer Interaction*, 16(2), 87–95.
- Pea, R., & Maldonado, H. (2006). WILD for learning: Interacting through new computing devices anytime, anywhere. In R. K. Sawyer (Ed.), *The Cambridge handbook of the learning sciences* (pp. 427–441). Cambridge: Cambridge University Press.
- Peters, K. (2007). m-Learning: Positioning educators for a mobile, connected future. *International Journal of Research in Open and Distance Learning*, 8(2), 1–17.
- Roschelle, J., & Pea, R. (2002). A walk on the WILD side: How wireless handheld may change computer-supported collaborative learning. *International Journal of Cognition and Technology*, 1(1), 145–168.

- Roth, W.-M., & Lee, Y.-J. (2007). "Vygotsky's Neglected Legacy": Cultural-historical activity theory. *Review of Educational Research*, 77(2), 186–232.
- Saba, F. (1988). Integrated telecommunications systems and instructional transaction. *The American Journal of Distance Education*, 2(3), 17–24.
- Saba, F. (2005). *Is distance education losing its identity? Or what should we call or field these days?* Paper presented at the 21st Annual Conference on Distance Teaching and Learning, University of Wisconsin-Madison.
- Saba, F., & Shearer, R. L. (1994). Verifying key theoretical concepts in a dynamic model of distance education. *The American Journal of Distance Education*, 8(1), 36–59.
- Sahin, S. (2008). The relationship between student characteristics including learning styles, and their perceptions and satisfaction in web-based courses in higher education. *Turkish Online Journal of Distance Education*, 9(1), 123–138.
- Sharples, M., Taylor, J., & Vavoula, G. (2005). Towards a theory of mobile learning. Retrieved from www.lsri.nottingham.ac.uk/msh/Papers/Theory%20of%20Mobile%20Learning.pdf
- Sharples, M., Taylor, J., & Vavoula, G. (2007). A theory of learning for the mobile age. In R. Andrews & C. Haythornthwaite (Eds.), *The Sage handbook of e-learning research* (pp. 221–247). Sage: London.
- Shearer, R. (2007). Instructional design and the technologies: An overview. In M. G. Moore (Ed.), *Handbook of distance education* (pp. 219–232). Mahwah, NJ: Lawrence Erlbaum Associates.
- Shen, R., Wang, M., Gao, W., Novak, D., & Tang, L. (2009). Mobile learning in a large blended computer science classroom: System function, pedagogies, and their impact on learning. *IEEE Transactions on Education*, 52(4), 538–546.
- Shin, N., Norris, C., & Soloway, E. (2007). Findings from early research on one-to-one handheld use in K–12 education. In M. van't Hooft & K. Swan (Eds.), *Ubiquitous computing in education* (pp. 19–39). Mahwah, NJ: Lawrence Erlbaum Associates.
- Tatar, D., Roschelle, J., Vabey, P., & Pennuel, W. R. (September, 2003). Handhelds go to school: Lessons learned. *The IEEE Computer Society*, 30–37.
- Taylor, J., Sharples, M., O'Malley, C., Vavoula, G., & Waycott, J. (2006). Towards a task model for mobile learning: A dialectical approach. *International Journal of Learning Technology*, 2, 138–158.
- Traxler, J. (2007). Defining, discussing, and evaluating mobile learning: The moving finger writes and having writ.... *International Review of Research in Open and Distance Learning*, 8(2), 1–12.
- Uden, L. (2007). Activity theory for designing mobile learning. *International Journal of Mobile Learning and Organization*, 1(1), 81–102.
- Vahey, P., Roschelle, J., & Tatar, D. (2007). Using handhelds to link private cognition and public interaction. *Educational Technology*, 47(3), 13–16.

- Vahey, P., Tatar, D., & Roschelle, J. (2004). Leveraging handhelds to increase student learning: Engaging middle school students with the mathematics of change. In *Proceedings of the 6th International Conference of the Learning Sciences* (pp. 553–560). Hillsdale NJ: Lawrence Erlbaum Associates.
- van't Hooft, M., Swan, K., Cook, D., & Lin, Y. (2007). What is ubiquitous computing? In M. van't Hooft & K. Swan (Eds.), *Ubiquitous computing in education*. Mahwah, NJ: Lawrence Erlbaum Associates.
- Vyas, R., Albright, S., Walker, D., Zachariah, A., & Lee, M. Y. (2010). Clinical training at remote sites using mobile technologies: An India-USA partnership. *Distance Education*, 31(2), 211–226.
- Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. London: Harvard University Press.
- Walker, K. (2006). Introduction: Mapping the landscape of mobile learning. In M. Sharples (Ed.), *Big issues in mobile learning: Report of a workshop by the kaleidoscope network of excellence mobile learning initiative*. University of Nottingham.
- Wang, M., Shen, R., Novak, D., & Pan, X. (2009). The impact of mobile learning on students' learning behaviours and performance: Report from a large blended classroom. *British Journal of Educational Technology*, 40(4), 673–695.
- Watson, R., & Coulter, J. (2008). The debate over cognitivism. *Theory, Culture, and Society*, 25(2), 1–17.
- Weiser, M. (1991). The computer for the 21st century. *Scientific American*, 265(3), 94–104.
- Winters, N. (2006). What is mobile learning? In M. Sharples (Ed.), *Big issues in mobile learning: Report of a workshop by the kaleidoscope network of excellence mobile learning initiative*. University of Nottingham.
- Zurita, G., & Nussbaum, M. (2007). A conceptual framework based on activity theory for mobile CSCL. *British Journal of Educational Technology*, 38(2), 211–235.

Why Open Educational Resources Are Needed for Mobile Learning¹

Rory McGreal

Abstract

Open Educational Resources (OER) constitute an important resource with the potential to facilitate the expansion of quality education. The relevance of OER is augmented by the exponential growth in online accessibility afforded by the wide range of new mobile devices. Athabasca University has been supporting a transition to course delivery via mobile devices for the past ten years, optimising websites for use on different devices. Driven by the copyright owners desire to apply technological protection measures (TPM), the need for OER is becoming more apparent. The disabling of specific functions such as copying and highlighting, and the prohibitions on format shifting and other changes, make it very difficult or impossible to use the content in educational contexts. This is reinforced by restrictive legislation prohibiting many educational uses such as re-using, mixing or repurposing the content. As mobile devices evolve, the content needs to be open so that it can be freely used without the restrictions imposed on proprietary content.

Introduction

Wireless technologies through the use of the Internet on new and more powerful networks are providing expanded access to learning opportunities in remote regions and in poorer barrios that were never linked to the “wired” world. At the same time, the growth in the number of Open Educational Resources (OER) and their ubiquitous accessibility on the Internet using the latest mobile devices is opening up access to learning in a way that was never envisaged by the most optimistic futurists.

¹ This chapter has been adapted from conference presentations at PEREL 2012, ICCGI 2012 and PCF4.

The diffusion and growing widespread availability of OER, combined with the extended reach of intelligent mobile phones, tablets and netbooks, have opened up new learning environments for previously isolated learners and for educational institutions that are innovative enough to break away from the traditional classroom mode of teaching. Time and space boundaries are no longer limiting factors, forcing scholars to congregate in one room or auditorium. The new affordances of the latest mobile technologies open up previously unimaginable prospects for access to learning, while at the same time giving educators new challenges in pedagogy and content delivery that maximise the value of this new open environment.

The latest mobile phones and tablets are becoming more affordable and available to anyone, anywhere. These ready-for-use mobile devices are removing existing barriers and are empowering citizens to connect to governments to access a wide range of information and services in a number of policy areas, including education. Furthermore, new-generation mobile phones, or “smartphones,” on the latest 3G and 4G networks that support multimedia — what can be described as a glut in new and sophisticated applications — are providing learners with increased accessibility to OER, not just written content, but also multimedia lessons, simulations and tests.

Background

Higher education institutions worldwide continue to face significant challenges related to providing increased access to high-quality education while containing or reducing costs. New developments in higher education all speak to the efforts on the part of the traditional higher education community, as well as more flexible providers such as open universities, to address these challenges. Such developments have the potential to increase access and flexibility in higher education. Basic education for all continues to be a goal that challenges (and will continue to challenge) many countries. Furthermore, some countries with significantly disadvantaged indigenous or other populations have set specific national goals aimed at addressing their needs. The current economic situation is likely to make these social goals more difficult as countries are faced with reduced budgets, as are donors. New approaches and methods are needed to ensure that all children and adults have an opportunity to learn throughout their lives.

Open Educational Resources

OER constitute an important resource with the potential to facilitate the expansion of quality education and learning opportunities worldwide. The William and Flora Hewlett Foundation (2010), the primary donor in the OER movement, supports the use of OER “to equalize access to knowledge for teachers and students around the globe.” OER is defined as “teaching, learning and research resources that reside in the public domain or have been released under an intellectual property licence that permits their free use or re-purposing by others” (Huyen, 2007). These resources include full courses, course materials, modules, textbooks, streaming videos, tests, software and any other tools, materials or techniques used to support access to knowledge. The free and open sharing of educational resources can serve to promote the building of knowledge societies and the reduction of the knowledge divide that separates nations, as well as the divide within societies themselves.

UNESCO supports the use of OER, stating that with the “goal of developing together a universal educational resource available for the whole of humanity ... [there is] hope that this open resource for the future mobilizes the whole of the worldwide community of educators” (UNESCO, 2002).

OER are important because, unlike closed proprietary content, OER can be re-used in many similar courses and even repurposed for use in different courses. For example, a psychology module can be re-used in a wide variety of psychology-related lessons or repurposed for use in an arts course. Localisation is also important: OER can be altered to suit the learners or teachers in their regional context.

OER as learning objects have been compared to LEGO blocks that allow users to construct courses from independent blocks or modules. Others feel that the use of OER is more complex, with some modules not fitting with others. And still others feel that OER units are much more complex, likening the assembly to molecular and even biological systems.

The concept of granularity is also important. An OER can be a course, unit, lesson, image, webpage, exercise or multimedia clip, but it must have a specified pedagogical purpose/context. Content instances can be assembled into a lesson. Lessons can be assembled into modules. Modules can be assembled into courses and courses can even be assembled together and become a full programme. All of these at their various levels of granularity can be OER.

Mobile Learning

The relevance of OER is augmented by the exponential growth in online accessibility afforded by the wide range of new mobile devices. In 1999, I was driving through a small village in the Philippines, when I slammed on the brakes, staring in disbelief at what I saw. There was a farmer, up to his knees in the water of a rice paddy and standing behind a plough and two oxen, and he was digital-messaging using SMS (Short Message Service). At that time, very few if any people in some developed countries were digital messaging. I found out later that at that time, the Philippines led the world in digital messaging per capita. Even today, the country claims to be the “SMS capital of the world” (Wiki@SMU, 2011).

As I stared at the farmer, I realised that the mobile phone he had in his hand was a smart computer — a computer more powerful than the one I had on my desktop only three years earlier. It is then that I developed my interest in mobile learning (mLearning). How could we use these small, powerful, connected computers for learning in both formal and informal contexts?

Today, there are more than 6 billion mobile subscriptions accounting for nearly 90% of the world’s population (7 billion). Significantly, more than 75% of these users are in developing countries, where there are more than 2 billion Internet connections. More than 90% of the world’s population now has access to cellular networks. And, more than 33% of the world’s population can now access the Internet — and that percentage is rising rapidly. Moreover, one-third of Internet users access the network only through mobile devices (International Telecommunication Union, 2012). The world is going mobile.

These mobile devices come in all shapes and sizes. Is it a computer in your phone or is it a phone in your computer? Tablets, e-books and netbooks are other

forms of mobile devices whose popularity is exploding. You can carry them anywhere; they are always available, always connected, and all are packed with auxiliary features. Even game players like the PlayStation and Nintendo are now available as mobile devices. The one laptop per child (and now one tablet per child) initiative of Negroponte's group based at MIT has opened up the market for cheap (less than \$200) mobile devices that are now available (and getting cheaper), with models being produced in India, Taiwan and elsewhere (Ricciuti, 2005). This digital convergence of mobile technologies with computers has created an environment where computing is pervasive. Your mobile device can be used not just for Internet access, but also for email and SMS, and as a camera, e-book, radio, game player, clock and even a telephone! With more than half a million apps now available, the uses of a mobile device are limited mainly only by the imagination of its creators.

Moreover, this is happening at an increasingly rapid pace. Moore's Law tells us that the cost of computing is halved every 18 months. Gilder's Law tells us that the cost of bandwidth is being reduced even faster. Storage capacity is growing so fast that one can consider the actual cost to be approaching zero. With cloud computing, network storage has become a real option for many institutions and individuals. The cloud can support immediate deployment, scalability, reliability, security, privacy and consistency, all coupled with user control.

OER and the Intellectual Commons

This growing trend towards mobile computing using the power of networks has opened the door for learners and teachers to access the world's knowledge from almost anywhere, at anytime. The Internet houses the world's treasure of knowledge. In this context, the role of OER in providing learners and teachers with learning content, applications, games and more is becoming increasingly more relevant. The Internet is the world's intellectual commons and OER renders this knowledge accessible to all. The world's knowledge is a public good that should be made available to everyone.

The UNESCO Chair in OER initiative is led by me and Dr Fred Mulder of the Open University of the Netherlands, with partners on all continents. The goal of this initiative is to support the Millennium Development Goals of UNESCO by building an international network of OER users (United Nations, 2011). Specifically in support of these goals, the Chairs are mapping the organisations around the world that are using OER, initiating a call for OER Chairs on all continents, initiating an international PhD programme for studying OER, and creating a knowledge network online to house research, articles and other information about OER.

Another Chair-supported initiative is that of the OER university (OERu), which aims to widen access and reduce the cost of tertiary study for learners who are excluded from the formal education sector. The initiative is an international innovation partnership of accredited universities, colleges and polytechnics co-ordinated by the OER Foundation, an independent educational charity. It does not confer degrees, but works in partnership with accredited educational institutions that provide assessment and credentialisation services on a fee-for-service basis. The OERu will provide pathways for students to achieve credible credentials for

approved courses based solely on OER. Students choose what is of interest to them and what meets their professional development needs from the “smorgasbord” of available open courses (OER Foundation, 2011).

OER at Athabasca University

Athabasca University (AU) has been supporting a transition to course delivery via mobile devices for the past ten years. As an open distance education university, AU delivers courses to more than 38,000 students across Canada and internationally. AU students can study, conduct research and acquire credit and degrees without ever having to be physically present at a university campus. This highlights the importance of unconventional but effective and efficient media for providing education and services to students. With the widespread availability of Internet technology, AU is now dependent on the use of the Internet to deliver course materials, to enable students to interact, to provide students with online library access, and to facilitate students in performing administrative tasks such as enrolling in or withdrawing from courses, and even writing exams, remotely. In line with the world trends, a growing number of students are accessing the Internet using their mobile phones, netbooks, tablets and other “smart” mobile devices.

AU online courses were first developed with desktop computers in mind. They were traditionally designed with the assumption that the user accessing the website had a large, wide, colourful screen and adequate bandwidth for downloading multimedia-rich pages from wired LANs. This assumption cannot be relied on anymore, given the pervasive use of small-screen, low-bandwidth mobile devices, as well as the latest 3G and 4G phones and tablets using wireless networks

AU has optimised its websites and some external sites that are linked from AU sites (specifically journal databases). These websites have been tested for visual integrity and functionality retention using some of the least capable mobile devices in order to ensure that these second-generation phones could still be used by those few students who have not yet upgraded to the more powerful 3G and 4G phones and tablets because those advanced devices can (for the most part) display the contents adequately (if not better in some cases) than many larger computer screens (McGreal, Cheung, Tin, & Schafer, 2005).

An early mLearning project at AU was the M-library. It was implemented in an attempt to build a platform for AU to develop an effective mobile-friendly library (Cao, Tin, McGreal, Ally, & Coffey, 2006). The Digital Reading Room (DRR), Digital Thesis and Project Room (DTPR), Digital Reference Centre (DRC), and AirPAC are some of the outcomes of the project. These projects formed part of a research focus on mLearning using style sheets and proxies (McGreal et al., 2005) and the development of a demonstration course specifically for use on mobile phones (Ally, McGreal, Schafer, Tin, & Cheung, 2007).

The Need for OER in Mobile Learning

OER are not just a good thing. One can argue that for mLearning applications, OER are essential. This need for OER is driven by the copyright controllers applying “technological protection measures” (TPM), meaning restrictive licensing as well as geographical and other restrictions.

Vendors can technically control how, when, where and with what specific brands of technological assistance users are able to access content and applications. For example, some e-book publishers abridge the content and ensure that it is so difficult if not impossible to read that it is “worthless” (Richard the Lionhearted, 2011). Moreover, they also deliberately cripple their devices to ensure that only their “approved” uses are possible. This is often problematic for disabled users. The visually impaired, for example, are denied use of a text-to-speech function, and in many cases cannot even increase the text size. Moreover, many proprietary systems still disable highlighting, annotating, hyperlinking and even using dictionary access — all features important for educational uses and essential for mLearning.

Different formats are nearly always problematic when mixing and mashing materials. OER can be changed and altered for use in different formats without permission. Chunking of information is fundamental to learning. Small pieces of text or even chapters are often all that people need. This chunking is not normally possible with vendor-controlled proprietary content (Bissell, 2011). Even simple printouts are not possible in many cases through removing the printing capability (or by prohibitory licensing or both) (Elibra & Starpath, n.d.) Hyperlinking is a normal learning activity that is often disabled. The devices are often purposely crippled, so that content and applications cannot be ported to other devices. Permissions of all kinds also need to be resought for tampering with the material for re-use, repurposing or mixing, even if fair use allows for it. This can become an impractical burden, putting a real damper on mLearning, which relies on the existence of large collections of open and accessible resources.

Even if a format becomes obsolete, users have no recourse when they cannot technically move their content to other devices and applications. Audio readers, for example, are becoming popular, especially among people with visual disabilities and with commuters on long trips (Elibra & Starpath, n.d.). Proprietors, however, can disable the ability of audio readers to access the content. Because of these digital locks, even the process of legally downloading proprietary content can prove to be onerous (Tony [eBookAnoid], 2010).

Mobile learning becomes problematic when mixing and mashing is not permitted. Proprietors wish to control and restrict the formats, devices and other circumstances that users may want to use the material in. The proprietors wish to lock in and control their customers. For example, the Amazon Kindle and Microsoft Reader use DRM (Digital Rights Management) restricted formats (AZW and LIT, respectively). On the other hand, Adobe’s PDF format allows for free use, but many older PDF documents cannot be reflowed to mobile devices easily. The open EPUB format is used by many publishers for production purposes, but then they convert it to their proprietary formats for public release.

Digital Rights Management (DRM)

DRM software enables copyright owners to control, limit and restrict what users can do with their content (Subramanya & Yi, 2006). Sometimes referred to as TPM (technological protection measures), it is also used as a tool to turn different uses of the content or application into a separate business deal, with restrictions and permissions. Because of this, some critics refer to DRM as Digital Restrictions Management (Brown, n.d.) These restrictions extend to both the hardware and the software. DRM can limit the devices that you are able to employ in accessing an application or content. It can restrict you to using the proprietor's website and purchasing the proprietor's materials under strict licensing conditions, determining how, when and where you can use the application or content, and with what devices. It is considered to be a necessary evil by proprietors to protect their content from pirates and viruses. DRM can (and has) been used to prevent lawful licensees from accessing their own purchased content. The DRM used in e-books and audiobooks blocks legitimate users from porting their content to other devices. In many cases, DRM has been used to delete legally purchased products from legitimate devices. Amazon, at one point, entered customers' computers and deleted their version of George Orwell's book *1984* (Fried, 2009). The Sony RootKit scandal was one example of a company deliberately using its DRM to surreptitiously insert a virus into licensees' computers without their knowledge or permission, causing significant disruption (Marson, 2005). Even so, DRM continues to prevent market competitors from participating and effectively stifles much innovation. Because of this, DRM can be seen as a barrier to mLearning.

Mobile learning demands flexibility and cannot live with proprietary restrictions that limit the capabilities of digital media. Digital books are no longer "books." In fact, Kroszer (2008), in commenting on the high price of e-books, points out that printed books now "offer a higher degree of flexibility, portability, and readability" than proprietary e-books. Mobile learning is also based on trust among the participating students and instructors. As they share resources, the participants must have confidence that their personal information is not used for purposes other than those of learning and sharing with other students and the teacher. Companies using DRM have a history of open-ended and indiscriminate collection of private information for unauthorised purposes, using DRM to disclose personal information for inappropriate purposes (Canadian Internet Policy and Public Interest Clinic, 2007). In many, if not most jurisdictions, companies have the right to invade your computers and networks without notice and without your permission, and to disable software for any real or imagined licence infraction.

Licensing

These proprietary licences (that users must accept in order to access the content or applications) are also a major impediment to mLearning. Never mind that some users inadvertently sold their immortal souls by agreeing to Gamestation's licence in an April Fool's Day prank (Matyszczyk, 2010). Licensing restrictions can add needless complications to downloading the content, sometimes making it so difficult that users simply give up. Fortunately this practice is not endemic.

Format shifting, as has been noted, is made technically difficult, and this is reinforced with restrictive licensing that prohibits the practice. Even if one wants to retain the same format, proprietary content is licensed to only one computer “for use solely on this device” (eBooks.com, n.d.), so learners who switch computers even with the same operating system are often restricted from doing so or, at a minimum, they must contact the owners and request special permissions and/or register with a company.

These licences also include clauses limiting downloads of content to one time on one computer for one user — and it is non-transferable, “for your use only.” Because the ubiquitous environment, as well as online classes (and classrooms), is considered public places under copyright law, you cannot distribute or broadcast such licensed content among students or even lend a device to them. Licences prohibit not only copying and printing, but also modifying, removing, deleting and augmenting (improving) or “in any way exploiting any of the eBook’s content.” This stipulation, along with the “sole device” stipulation, effectively negates any attempts at mLearning using such software, even if institutions are prepared to pay, pay again and keep paying, for the same licences until they expire. And, if institutions don’t keep paying, they may no longer be able to access data or records linked to that product. Licences also prohibit the transfer of content to other students when teachers wish to use mobile devices with a different group of students in later semesters.

Moreover, software licensing exempts software publishers from *all* liability under consumer protection law. There is no “product” to purchase. Not only does the “purchaser” have no rights, but no requirements are placed on the publisher nor is there any requirement that a programme even work. And the publisher has no liability when it turns off the content or software for whatever reason, legitimate or otherwise. A publisher can also change these and other clauses of the contract at any time. In fact, whenever software is upgraded, the contract can be changed and often is, but never for the benefit of the user (Brown, n.d.).

For those educators who wish to avail themselves of their fair dealing (or fair use) rights, these licences effectively negate them along with the right of first sale that normally allows buyers to resell their purchases (EBIA, 2010). The licence represents a contract agreed to by the licensees to not avail themselves of their fair dealing rights or first sale rights. Contract law trumps fair dealing (Horava, 2009):

“If a library and a publisher agree in a contract that fair dealing will not apply to activities that are specified in the contract, then the contract’s provisions prevail regardless of what the Copyright Act provides.”

Contracts can even be used to extend the copyright extension from 70 years after an author’s death to an eternity (Brown, n.d.). One U.S. Congressperson noted a preference for copyright as lasting “forever less a day” (U.S. Congress, 1998).

Geographical Restrictions

The predicament of an iPad owner in Luxembourg puts the matter of geographical restrictions in a clear light. Even though he would like to legally purchase content, he cannot because it is not available in his country. He can find material on pirate sites, but he wants to buy legally and cannot. Another commentator talks about

user “anger,” noting that geographical restrictions using DRM are “the most pressing issue” (Americaneditor, 2010). Google’s “Geographical Constraint” error message, along with YouTube’s “This video is not available in your country,” are notorious examples of this, when users get an error message, when they attempt to download books or videos that are not licensed in their country. For instructors, of course, a legal purchase is mandatory, so in many countries they are effectively excluded from using vast amounts of relevant content (Wolf, 2011). For borderless online courses from institutions that deliver lessons to many different countries, the restrictions effectively prevent them from using this content. The copyright owners are encouraging piracy through these geographical controls that prohibit legitimate uses.

Conclusion

The copyright controllers have declared war on technology, using lawsuits, legislatures and clever public relations to restrict the ability to sell and use new technologies. Even “homeland security” is trumped by copyright protections, and the \$40 billion entertainment industry is imposing its views on the \$500 billion technology industry (Gary Shapiro, cited in Borland, 2002).

Copyright controllers are trying to entrench their monopoly. They want to control “in infinite detail all use and duplication of material, monitor that use, and possibly charge for it on a transactional basis if they don’t block it out of hand” (Lynch, 2001). The copyright controllers have waged a continuous war, aiming to extend their rights at the expense of education and the general public. Barlow (1996, p. 15) warned, “The greatest constraint on your future liberties may come not from government but from corporate legal departments labouring to protect by force what can no longer be protected by practical efficiency or general social consent.”

So, rather than fighting head-on these rich and powerful interests, educators can bypass them by using OER. Publicly financed content creations should remain open to all and rendered accessible to the public over the Internet. Rather than remain trapped behind the overly restrictive proprietary environments that publishers are creating, educators can make use of OER to localise and mix and match the materials on whichever device, application or operating system they choose, wherever they live. As mobile devices evolve, the content needs to be open so that it can be freely used without the restrictions imposed on proprietary content.

References

- Ally, M., McGreal, R., Schafer, S., Tin, T., & Cheung, B. (2007). Use of mobile learning technology to train ESL adults. *Proceedings of the 6th International Conference on Mobile Learning*, Melbourne.
- Americaneditor. (2010, March 1). The eBook wars: Making peace. Retrieved from <http://americaneditor.wordpress.com/tag/book-repository/>
- Barlow, J. P. (1996). Selling wine without bottles: The economy of mind on the global net. In *High noon on the electronic frontier: Conceptual issues in cyberspace* (pp. 9–34). Cambridge MA: MIT Press.

- Bissell, A. N. (2011, July). OER and open licenses: The dual-pub solution. Retrieved from http://independent.academia.edu/AhrashBissell/Papers/778168/OER_and_open_licenses_the_dual-pub_solution
- Borland, J. (2002, September 17). Trade group: P2P not illegal or immoral. Retrieved September 28, 2002, from http://news.com.com/2100-1023-958324.html?tag=cd_mh
- Brown, P. (n.d.). What is DRM? Digital restrictions management. Retrieved from www.defectivebydesign.org/what_is_drm
- Canadian Internet Policy and Public Interest Clinic. (2007, September). Digital Rights Management and consumer privacy: An assessment of DRM applications under Canadian privacy law. Retrieved from www.cippic.ca/uploads/CIPPIC_Report_DRM_and_Privacy.pdf
- Cao, Y., Tin, T., McGreal, R., Ally, M., & Coffey S. (2006). The Athabasca University Mobile Library Project: Increasing the boundaries of anytime and anywhere learning for students. *Proceedings of the 2006 International Conference on Wireless Communications and Mobile Computing*, pp. 1289–1294.
- EBIA. (2010, September 29). eBook License agreement. Retrieved from www.ebia.com/Copyright/Licenses/eBook
- eBooks.com. (n.d.). Customer license. Retrieved from www.ebooks.com/information/customerlicense.asp
- Elibra and Starpath. (n.d.). All about ebooks. Retrieved from www.starpath.com/elibra/about_index.htm
- Fried, I. (2009, July 17). Amazon recalls (and embodies) Orwell's 1984. *CNet News*. Retrieved from http://news.cnet.com/8301-13860_3-10289983-56.html
- Horava, T. (2009). Ebooks licensing and Canadian copyright legislation: A few considerations. *Canadian Journal of Library and Information Practice and Research*, 4(1). Retrieved from <http://journal.lib.uoguelph.ca/index.php/perj/article/viewArticle/929/1475>
- Hylen, J. (2007). Giving knowledge for free: The emergence of Open Educational Resources. Retrieved from www.oecd.org/dataoecd/35/7/38654317.pdf
- International Telecommunication Union (2012). Global mobile cellular subscriptions, total and per 100 inhabitants 2001–2011. Retrieved from www.itu.int/ITU-D/ict/statistics/
- Kroszer, K. (2008, May 28). The eBook problem and the eBook solution. Retrieved from <http://booksquare.com/the-ebook-problem-and-the-ebook-solution/>
- Lynch, C. (2001). The battle to determine the future of the book in the digital world. *First Monday*, 6(6), 66. Retrieved from http://firstmonday.org/issues/issue6_6/lynch/index.html
- Marson, I. (2005). Sony settles “rootkit” class action lawsuit. *CNet News*. Retrieved from http://news.cnet.com/Sony-settles-rootkit-class-action-lawsuit/2100-1002_3-6012173.html

- Matyszczyk, C. (2010, April 16). Online game shoppers duped into selling souls. *CNet News*. Retrieved from http://news.cnet.com/8301-17852_3-20002689-71.html
- McGreal, R., Cheung, B., Tin, T. & Schafer, S. (2005). *Implementing mobile environments using learning objects*. Paper presented in the Athabasca University Digital Reading Room, IEEE International Workshop on Wireless and Mobile Technologies in Education Conference (WMTE) 2005, Tokushima, Japan, IEEE.
- OER Foundation (2011). Towards an OER University. Retrieved from http://wikieducator.org/Towards_an_OER_university:_Free_learning_for_all_students_worldwide
- Ricciuti, M. (2005). The \$100 laptop moves closer to reality. *CNet News*. Retrieved from http://news.com.com/The+100+laptop+moves+closer+to+reality/2100-1044_3-5884683.html
- Richard the Lionhearted. (2011, September 5). Comments on five alternatives to expensive textbooks by Ritika Puri. *Globe and Mail*. Retrieved from www.theglobeandmail.com/globe-investor/personal-finance/household-finance/five-alternatives-to-expensive-textbooks/article2145784/comments/
- Subramanya, S. R., & Yi, B. K. (2006). Digital Rights Management. *Potentials IEEE*, 25(2), 31–34. Retrieved from http://ieeexplore.ieee.org/xpl/freeabs_all.jsp?arnumber=1649008. doi:10.1109/MP.2006.1649008
- Tony [eBookAnoid]. (2010, July 29). eBooks: The problems of actually getting them into your eReader. Retrieved from www.ebookanoid.com/2010/07/29/ebooks-the-problems-of-actually-getting-them-into-you-ereader/
- UNESCO (2002). *Forum on the impact of open courseware for higher education in developing countries*. Final report. Retrieved 12 October 2013 from: <http://unesdoc.unesco.org/images/0012/001285/128515e.pdf>
- United Nations (2011). *The Millennium Development Goals report*. Retrieved 12 October 2013 from: [http://www.un.org/millenniumgoals/pdf/\(2011_E\)%20MDG%20Report%202011_Book%20LR.pdf](http://www.un.org/millenniumgoals/pdf/(2011_E)%20MDG%20Report%202011_Book%20LR.pdf)
- U.S. Congress. (1998). Mrs. Bono's address to the House. Vol. 144. *Congressional Record House*. Retrieved from http://frwebgate.access.gpo.gov/cgi-bin/getpage.cgi?position=all&page=H9952&dbname=1998_record
- Wiki@SMU (2011). Digital media in Philippines. Retrieved from https://wiki.smu.edu.sg/digitalmediaasia/Digital_Media_in_Philippines
- William and Flora Hewlett Foundation. (2010, October). Education program: Strategic plan. Retrieved from www.hewlett.org/uploads/documents/Education_Strategic_Plan_2010.pdf
- Wolf, J. S. (2011, June 1). iPad owner in Luxembourg. Retrieved from www.mobileread.com/forums/archive/index.php/t-114431.html

Design of Contextualised Mobile Learning Applications

Marcus Specht

Abstract

This chapter discusses several issues about linking the user experience to the current context of use. The linking of the mobile learning support to the current context is seen as key to efficient and effective design of mobile learning applications. The author introduces the Ambient Information Channel (AICHE) model as an approach for building contextualised learning support. The AICHE model and its main components and process are introduced and example applications built from the model are given. The model gives a guideline for the development of applications from the use of sensor information to the specification of the instructional logic. The main added value of the model lies in the systematic support for re-use of instructional patterns for ubiquitous learning, and also in the re-use of technological components for different levels of the application model. The example applications built with the AICHE model range from a simple notification system to the complex installation of embedded sensor technology and multiple displays — that is, input and output channels.

Introduction

Mobile user interfaces have changed dramatically in the last five years, since the introduction of the iPhone and the iPad touch-based interfaces, which are more or less the standard for sub-laptop devices. In the development of user interfaces for mobile learning (mLearning), several aspects have been studied. For example:

- *Mobile interface design:* From a mobile usability perspective, the reduced screen estate has been an essential issue for Human–Computer Interaction (HCI) research and how to design user interfaces for small screens. This is linked to questions of how to enable navigation in complex information spaces with a reduced information channel such as the small display on

mobile phones. Today, there are clear style guides and design patterns for mobile user interfaces on smartphones for the major platforms. There are also increasingly more ways to ensure a consistent interaction design across different platforms such as ambient and situated displays, tablets and smartphones. HCI research has also developed flexible methods for mapping user interface functionality to different user interfaces.

- *Mobile legacy access*: The access of legacy content and learning management solutions has been a topic of research (Glahn & Specht, 2010). Nowadays, most existing learning management systems (or LMS) provide mobile access to the main functionality, but it is still a challenging task to prioritise and structure the access to the functionality and to decide which functionality is actually helpful in a mobile context.
- *Contextualised learning support*: The contextualised filtering of information and the provision of system functionality based on mobile phone sensors such as location and compass have recently become more popular (Brown, 2010). Even in the late 1990s, new kinds of user interfaces were explored to enable physical movement of users in museum environments for navigation in the information space (Oppermann & Specht, 2000). Recent developments link mobile apps more to the current context of the user and use of the information — about location, other information sources in the vicinity, or the social context of a person — to filter information and functionality in the mobile application.
- *Seamless and cross-context support*: Mobile apps are being combined and integrated with cloud-based services and multiplatform applications to enable seamless and cross-context performance support for learning (Wong & Looi, 2011). For learning support, this tackles the issue of orchestration of learning (Dillenbourg, 2011) across multiple devices and in ubiquitous learning environments.

The following sections will detail the contextualisation of mobile applications and the seamless support across contexts. The Ambient Information Channel (AICHE) model and a methodology to design mobile applications and user interfaces that take into account the context of use will be presented (Oppermann & Specht, 2000). The AICHE focuses on the design of integrated experiences that synchronise the user services provided via mobile technology and the resources available in the user's environment, situation or context.

First, the different notions of “context” and the context model used as a basis for the AICHE model are outlined below. Then the core components and the processes of the AICHE model are illustrated. Finally, several example applications are described and used to illustrate the use of the AICHE model in design and implementation of mLearning for synchronised and integrated learning experiences.

Linking Mobile Learning to the Real World

Mobile apps and user interfaces linked to the current context of use ranges from apps that filter content according the current time or community watching a TV programme to the visual head-up-displays (HUD) created according to the current user position and viewing direction in mobile-augmented reality apps (Specht, Ternier, & Greller, 2011).

When looking at the history of mLearning, Traxler (2009) defines several phases of mLearning conceptions. While at the beginning of mLearning there was a focus on the mobile technology as such, this changed gradually to a focus on the mobility of the learner and the seamless access to learning support.

In a literature review of mLearning applications, Frohberg, Göth, and Schwabe (2009) defined different dimension for classifying mLearning support. One of the dimensions has been the link of the mLearning functionality to current user context. The study identified only a small percentage of the applications actually using the current context of use for supporting the learner. Most of the applications simply provided access to information and services independent of the context. In their study, the authors also distinguished three different forms of context taken into account for learning support: formalised context, physical context and socialising context (Frohberg et al., 2009).

The field of context-aware computing has developed a variety of context definitions mostly starting from location or object context. In a pragmatic approach, Zimmermann, Lorenz, and Oppermann (2007) give a workable definition of context: “any information that can be used to characterise the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between the user and the application, including the user and the applications themselves.” Moreover, Zimmermann et al. clustered context into five fundamental categories:

- Individuality – Includes information about objects and users in the real world (with respect to users, their profile can include preferences, acquired-desired competences, learning style, etc.). This facet of context can also refer to information about groups and the attributes or properties the members have in common.
- Time – Refers to tempo co-ordinates. These can range from simple points in time to ranges, intervals and a complete history of entities.
- Location – Refers to physical and/or virtual spatial co-ordinates. These can be described based on quantitative or qualitative location models, which allow working with absolute or relative positions, respectively.
- Activity – Refers to what the entity wants to achieve and how. This reflects the entity’s goals, tasks and actions.
- Relations – Captures the relation an entity has established with other entities, and describes social, functional and compositional relationships.

For example, contextual and location-based mLearning in action was part of an “Education in the Wild” initiative described in an Alpine Rendez-Vous workshop report (Brown, 2010). Context-aware technologies in this sense give an option to augment the learner’s environment with relevant and supportive information and services.

Ambient Information Channel (AICHE) Model

The AICHE model allows the describing of patterns of contextual learning support in a generalised way. It integrates research of the last ten years about context-aware computing, information modelling, adaptive hypermedia and instruction, instructional design, and human-computer interaction.

AICHE uses a simple metaphor of information channels that are ambient all around us. Technically speaking, the underlying assumption is that one can access any kind of information as documents, messages, annotations and services in any given situation. Based on this assumption, one has the freedom to plan for educationally sensible interactions and scaffolds as described in the phases of Luckin's model (2010) and does not need to think about technical barriers. In her model on the ecology of resources, Luckin (2010) looks at several changes and extensions of context from a multidisciplinary and multidimensional perspective. Resources in a future learning ecology are distributed across devices and multiple computer-based technologies, multiple learners and a range of locations. As a key component of instructional design for ambient learning support, it becomes essential to have multidimensional user modelling and scaffolding that involves meta-cognition, affect and cognition.

Taking into account the current technological developments in contextualised learning support as pointed out in (Specht et al., 2012), the channels connected to ambient displays can transport multimodal information via visual, auditory, haptic, gustatory or olfactory channels.

All *channels, users and artefacts* in AICHE have a set of meta-information connected to them as soon as they are instantiated in the computational model. Basically, this meta-information holds all contextual information about a channel, such as location, ID, content, environment, relations and activity. Channels can be bound to artefacts in the physical environment and these artefacts can be configured to indicate the channel information in a special way. Artefacts also offer a kind of handle or affordance for the end-user to access or manipulate the channels.

Channels, users and artefacts make use of sensor information to aggregate and match contextual information according to the instructional logic. This is related to the filters in the "ecology of resources" model of Luckin. As a simple example, a channel and a user would have a location sensor attached to them and the channel would continuously scan for the best way to be displayed at the changing location of the user. In an AICHE model, artefacts, channels and users are linked with a special logic or instructional design. Two core concepts of Luckin's framework are the Zone of Available Assistance (ZAA), which describes the variety of resources that could provide assistance to a learner, and the Zone of Proximal Adjustment (ZPA), which contains the subset of resources from the ZAA that are appropriate to the learner's needs.

The following sections describe the AICHE structure and interaction of its components in more detail.

AICHE Structure

The contextual learning applications in AICHE work in four layers (Specht, 2009). These layers are related to technical infrastructures and solutions engineered for context-aware systems, but have been extended with specific components relevant for contextual learning.

The four layers are:

- a. *Sensor layer*, in which all sensor information is handled. Key issues on the sensor layer are the integration of wide variety of sensor types, push-and-pull data collection from sensors, and mobile and infrastructural sensors.

- b. *Aggregation layer*, in which sensor information is combined into sensible entities and relations, and set in relation to channels and users. In the aggregation layer, key processes such as aggregation and enrichment take place (described in more detail below).
- c. *Control layer*, in which the instructional logic is specified. The logic makes use of the aggregated sensor information and enriched entities and combines them in instructional designs. In ubiquitous learning support, this layer needs interfaces to the real-world objects and digital media, as both are used in integrated instructional designs — that is, the performance or a learner in a certain learning activity can influence and change the status of digital media, learning activities, as well as physical objects in the real world.
- d. *Indicator layer*, in which all visualisations and feedback for the user are described. Together with the sensor layer, the indicator layer holds most of the user interface components with which the user interacts.

Earlier publications have shown how to integrate contextual learning support with real-world learning environments in museums, industry and everyday life examples (Zimmermann, Specht, & Lorenz, 2005) and described several applications based on these layers and the components.

AICHE Components

In the four layers, different components are used. These are mainly sensors, channels, artefacts and control structures.

- *Sensors* are all kinds of objects that can measure something. Examples include a thermometer measuring the current temperature or a multiple-choice test measuring the student's knowledge about a topic. An important point is that depending on the instructional goals, the sensor data can also be used as content in an information channel. This is especially interesting for learning support that targets reflection and learning based on this sensor data.
- *Channels* are used to deliver content and services to users. A channel can be a simple output channel delivering information to the user via different modalities, or it can be a combined input/output channel. Input channels allow a user to feed information into the system and therefore interact with the system. Input channels can be bound to sensors and output channels can be bound to artefacts or indicators. The content presented in a channel can be considered to come from a ubiquitous persistence system as “the cloud” and to be described with metadata. Technical problems, such as deciding the optimal format to deliver content to a channel, are solved based on a matching process of available artefacts, the channel, and the content metadata in the AICHE model.
- *Artefacts* are augmented physical objects that allow users to interact with information channels. So, artefacts can be displays to read information and interaction devices to give input. Artefacts are also interaction devices with which the user can produce input such as keyboards, audio recorders, video recorders, text recognition engines, sense-based interaction devices and others.

- *Control structures* combine the entities and a logic description of their dependencies. Simple control structures can sequentially activate the visibility of different channels depending on sensor information. Complex control structures can describe collaborative learning scenarios with a complex interplay of sensors, artefacts, channels and user behaviour. For a combination of sensors, channels, artefacts and the control structures, we can define several processes in detail, such as aggregation, enrichment, synchronisation and framing.

The components in AICHE are related to the resources in the ecology of resources framework of Luckin (2010). In her model, she distinguishes three types of resources: 1) knowledge and skills; 2) tools and people; and 3) environment. The availability and usefulness of these resources are subject to a variety of filters, which range from curricula to classroom arrangements and schedules. Furthermore, resources and filters influence each other via relationships. In this ecology of learning resources, the “more able partner” role can be taken by technology, peers or educators. In the AICHE model, filters are defined by contextual information that can be attached as metadata to resources or components. Seen from an application modelling perspective, AICHE needs a model representation to define the instructional and application logic.

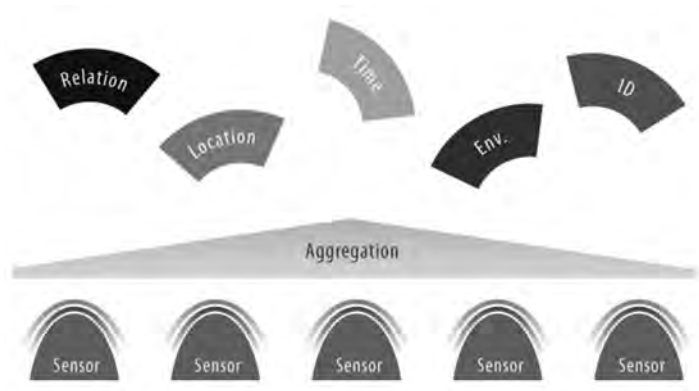
AICHE Processes

Building AICHE applications includes several steps that range from technical integration to instructional logic implementation. The main processes involved are described below.

Aggregation

To achieve contextual learning support, it is important to aggregate sensor information to make it meaningful for the learning objectives. For example, the location of a GPS device carried by a user is only meaningful when it is connected to the user’s perceivable environment and relevant learning tasks. Aggregation can be a simple process of converting scales of sensor data, but it can also involve complex computations of sensor input, such as researched in sensor fusion (Figure 5.1). How important the type of aggregation is becomes clear when aggregating sensor information such as time. Time can be aggregated on a very abstract granularity level, such as season or time of year. It can also be aggregated on the level of beginning or end of a special event as a lecture. Considering the relevance to the learning objectives, in most cases an aggregation process should already take into account the interpretation of the sensor data in a meaningful way related to the objectives. Figure 5.1 shows an abstract example of different sensor values that can be aggregated on higher level sensor categories as described in the operational definition.

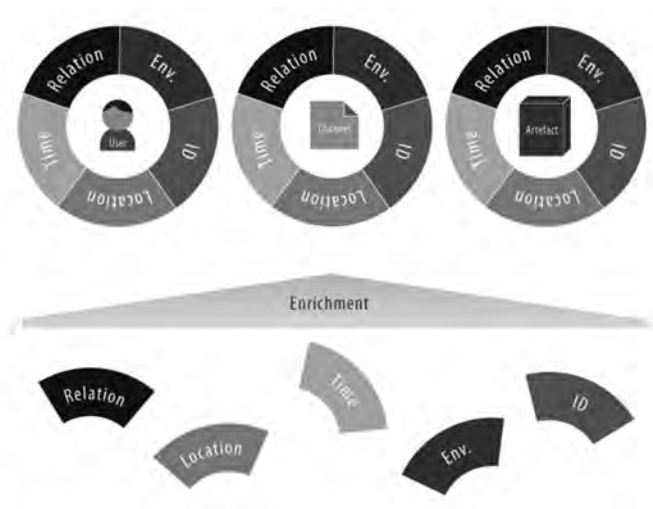
Figure 5.1: Aggregation of sensor information in AICHE.



Enrichment

In the process of enrichment, channels, users and artefacts are enriched with aggregated sensor information (Figure 5.2). Either by a specified matching function or by static binding, artefacts and users know which sensors can be used for them and what kind of information they can deliver. As a consequence of enrichment, each artefact, user and channel is enriched with context metadata. In principle, the enrichment process includes a kind of entity relationship modelling process of the application entities and their relations (as in Zimmermann et al., 2005). Furthermore, different types of aggregation of sensor information can be used with different entities in the enrichment process.

Figure 5.2: Enrichment of application entities with sensor information.

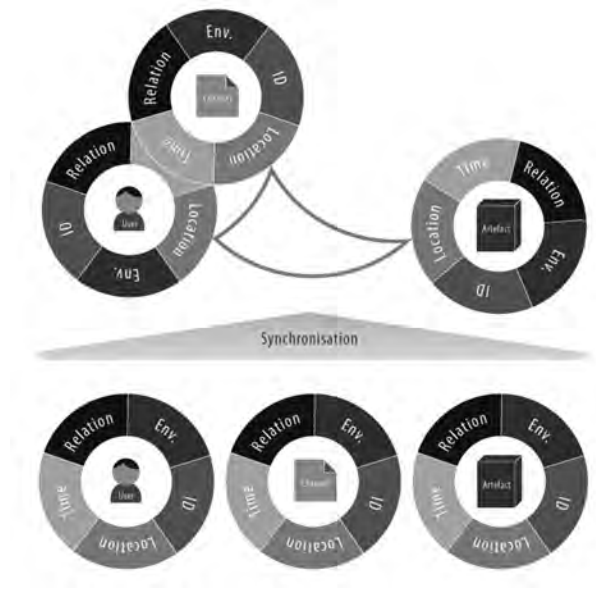


Synchronisation

In the synchronisation process, the enriched users, artefacts and channels are synchronised based on a described logic (Figure 5.3). For example, the location of an artefact and the user are used to display a channel via an artefact. Synchronisation is at the core of every contextualised learning support and it is related to the scaffolding and adjustment phase in the model of Luckin (2010).

At one level, synchronisation is the result of a matching process — that is, the user location is matched with location metadata of channels and artefacts. At a second level, synchronisation has to be based on instructional designs that specify the logic of the matching.

Figure 5.3: Synchronisation of different entities and their contextual information.



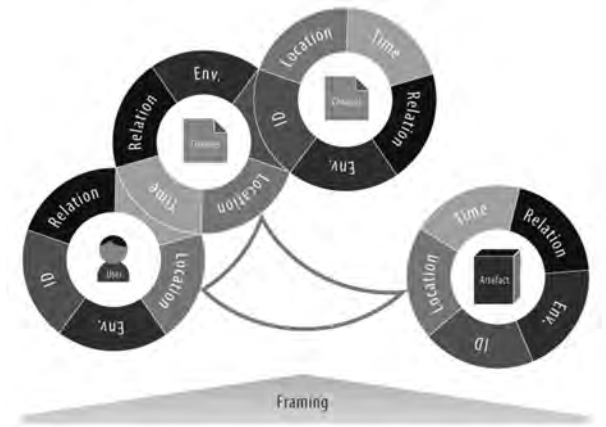
Location-based learning applications are one example in which mostly the location is used for synchronising a user, a channel and artefacts in certain locations. As a simple educational example, consider a podcast channel that could be delivered to a user in a museum as soon as the user enters a room. In the example in Figure 5.4, the time is also taken into account for synchronisation. For the museum visitor, this could mean that, depending on the time of the day, different information will be displayed through the channel. This would require an aggregation of the time sensor onto a categorical parameter of daytime periods such as morning, noon and evening, and a specification of the podcast selection for every day's period and location. The added value of the AICHE model is that it enables re-use of a logic pattern in different contexts, not only in the sense of the instructional logic but also in the sense of the necessary sensor technology, aggregation components, enrichment and entity relationship modelling.

Framing

The display of the synchronised channels can also be contrasted with relevant reference information in the instructional design. The framing process is mostly related to feedback and stimulation of meta-cognitive processes. For example, the channel presented to the learner can be presented in combination with a second channel displaying an overview of related contents or meta-information about all artworks from the same artistic period. Especially with augmented reality applications or dual-screen applications, framing gets an important role as most artefacts and real-world objects with which we learn need to be framed in the instructional context. The framing process is highly related to research that is currently looking into dual-screen instructional designs — see, for example,

Chang, Hsu, and Yu (2011) on classrooms, and Verpoorten, Westera, and Specht (2011) in fostering reflection in online environments.

Figure 5.4: Framing of an ambient information channel with a second channel.



Example Applications Based on AICHE

Time-Based Notification for Reflection Support

The first example application is a simple notification system collecting input from participants on a time-based trigger. Similar approaches are used in experience sampling systems. In the study used for evaluation, students have been notified and asked to reflect on their daily learning process via a mobile phone. The study took place in an “experiment week” which invited students to discover the work of the Learning Media Laboratory through participation in empirical experiments. At the end of the day, a presentation provided an overview of mobile technologies for learning. Afterwards, the participants were introduced to the exercise to be done in the next four days. The experiment was described to students as a reflection exercise in which they were encouraged to amplify their awareness of their daily activity as learners. The results have been published in Tabuenca, Verpoorten, Ternier, Westera, and Specht (2012).

The application uses only one basic sensor: time. The time sensor is aggregated only so that it provides a trigger for sending out the notification at a certain time of the day. Related to the learning objective, sending out the reflection trigger only at a certain time of the day is relevant. Furthermore, the application uses one artefact, which is the user’s smartphone. The only relevant characteristic about the personal smartphone is that it is directly linked to the user’s environment and moving with the user. As channels, the application includes an output (notification) channel and an input channel (online quiz). Both channels are bound to the user’s smartphone. No framing is used in the application.

Location-Based Fieldwork and Data Collection

The second example application is the ARLearn toolkit, which uses situated notifications, contextualised task assignments, and data collection on a field trip (Ternier, Klemke, Kalz, Van Ulzen, & Specht, 2012). Every year, students at

the School of Cultural Sciences of the Open Universiteit take part in a field trip to Florence, where they study the visual art in its original context. During this trip, students are trained on skills such as collecting data in the field, conducting a literature study, and developing their own research questions and oral presentation skills.

Part of the study group that visited Florence in the autumn of 2010 and 2011 was equipped with smartphones. Via the smartphone, students received audio notifications containing either information or assignments relative to their location. They could also record annotations and personal remarks. All information was collected in the cloud for later creation of a portfolio. As sensor information, the application uses time, userid, location, compass and task assignment. The information is aggregated in different ways. First, all sensors are used to enrich the user information for collecting and aggregating information later used in the portfolio. All locations of a user are recorded and the media created via the input channels are meta-tagged with the available sensor information. As artefacts, not only are the user's smartphones used, but also the physical buildings and the artworks in the current environment of the user. As channels, the input and output channels are combined with the user's smartphone. By logging the user activity in the channels and meta-tagging the created media with the available sensor information, collaborative framing is also done, as all students and their educators can see what remarks and annotations the other students have created.

Energy Awareness Displays

The third example application is the most complex one. It has been implemented in the context of an innovative project supported by the SURF foundation (Börner, Kalz, & Specht, 2012).

The project elaborated on and developed an infrastructure that supports energy awareness displays in office buildings — one that uses existing services and includes individual energy consumption information. Based on the supporting infrastructure, two example applications to access and explore the information have been implemented. For evaluation, the infrastructure has been set up in the Chiba building at the Open Universiteit campus in Heerlen and the example applications were deployed among a group of employees working in that building. Besides work to measure the effectiveness of the prototype, also conducted were an informative study, a comparative study, a user evaluation of the prototype, and a design study.

The design of the energy awareness displays uses the following components, in keeping with the AICHE framework:

- sensors about individual- and building-related energy consumption and about personal logging of energy consumption
- artefacts, such as the objects in the office environment that use energy and ambient displays embedded in the office environment
- several input and output channels, combined with the artefacts

Users can put in the location of the workplace of their choice on the ambient displays, and these have also been used to display energy consumption information. Personalised statistics have been bound to the personal smartphone of a user.

Conclusion

As shown in the examples, the AICHE model can support a range of applications, from simple notification applications to complex ubiquitous installations to support learning. On the one hand, the model supports the re-use of single components and even technical implementation of these (such as certain sensor components and aggregations of the sensor data). On the other hand, the model integrates instructional design components in that it gives clear options of synchronisation and framing based on the available technology components that can be used in the implementation of an instructional design. Therefore, AICHE typically represents a technology enhanced learning model in that it integrates technologically available components (technology) in an instructional (learning, teaching) way to achieve educational enhancements (effects).

In future work, the author and colleagues plan to implement an AICHE application development framework that links to different multi-device development environments to support the fast-prototyping of new applications in which different instructional designs can be implemented rapidly for empirical evaluation and innovation of ubiquitous learning.

References

- Börner, D., Kalz, M., & Specht, M. (2012). Energy awareness displays: Designing a prototype for personalised energy consumption feedback at the workplace. In *Proceedings of the 2012 IEEE 7th International Conference on Wireless, Mobile and Ubiquitous Technology in Education* (pp. 211–213). 27–30 March 2012, Takamatsu, Japan: IEEE Computer Society.
- Brown, E. (2010). *Education in the Wild: Contextual and location-based mobile learning in action*. Report from the STELLAR Alpine Rendez-Vous Workshop Series. Nottingham, UK: Learning Sciences Research Institute, University of Nottingham.
- Chang, T.-W., Hsu, J.-M., & Yu, P.-T. (2011). A comparison of single- and dual-screen environment in programming language: Cognitive loads and learning effects. *Educational Technology & Society*, 14(2), 188–200.
- Dillenbourg, P. (2011). Design for orchestration. Retrieved July 1, 2011, from www.teleurope.eu/pg/file/read/93714/whitepaper-on-orchestration
- Frohberg, D., Göth, C., & Schwabe, G. (2009). Mobile learning projects: A critical analysis of the state of the art. *Journal of Computer Assisted Learning*, 25(4), 307–331. doi:10.1111/j.1365-2729.2009.00315.x
- Glahn, C., & Specht, M. (2010). *Embedding Moodle into ubiquitous computing environments*. In M. Montebello et al. (Eds.), 9th World Conference on Mobile and Contextual Learning (MLearn2010) (pp. 100–107). October, 19–22, 2010, Valletta, Malta.
- Luckin, R. (2010). *Re-designing learning contexts: Technology-rich, learner-centred ecologies*. London: Routledge.
- Oppermann, R., & Specht, M. (2000). A context-sensitive nomadic exhibition guide. *Handheld and Ubiquitous Computing Lecture Notes in Computer Science*, 1927, 127–142). Springer. doi:10.1007/3-540-39959-3_10

- Specht, M. (2009). Learning in a technology-enhanced world: Context in ubiquitous learning support. Inaugural address. September, 11, 2009, Heerlen, The Netherlands: Open University of the Netherlands.
- Specht, M., Börner, D., Tabuenca, B., Ternier, S., De Vries, F., Kalz, M., Drachsler, H., & Schmitz, B. (2012). RTST trend report. Lead theme: Contextualisation. Deliverable 1.7 of STELLAR network of excellence. Heerlen, The Netherlands.
- Specht, M., Ternier, S., & Greller, W. (2011). Mobile augmented reality for learning: A case study. *Journal of the Research Center for Educational Technology*, 7(1). Retrieved January 18, 2012, from www.rcetj.org/index.php/rcetj/article/view/151
- Tabuenca, B., Verpoorten, D., Ternier, S., Westera, W., & Specht, M. (2012, September). *Fostering reflective practice with mobile technologies*. 2nd Workshop on Awareness and Reflection in Technology-Enhanced Learning. ARTEL/EC-TEL 2012, Saarbrücken, Germany.
- Ternier, S., Klemke, R., Kalz, M., Van Ulzen, P., & Specht, M. (2012). ARLearn: augmented reality meets augmented virtuality [Special issue]. *Journal of Universal Computer Science: Technology for Learning Across Physical and Virtual Spaces*.
- Traxler, J. (2009). Current state of mobile learning. In M. Ally (Ed.), *Mobile learning: Transforming the delivery of education and training*. Edmonton, AB: Athabasca University Press.
- Verpoorten, D., Westera, W., & Specht, M. (2011). Reflection amplifiers in online courses: A classification framework. *Journal of Interactive Learning Research*, 22(2), 167–190.
- Wong, L.-H., & Looi, C.-K. (2011). What seems do we remove in mobile assisted seamless learning? A critical review of the literature. *Computers & Education*, 57(4), 2364–2381. Elsevier Ltd. doi:10.1016/j.compedu.2011.06.007
- Zimmermann, A., Lorenz, A., & Oppermann, R. (2007). An operational definition of context. In *Proceedings of 6th International and Interdisciplinary Conference (CONTEXT 2007)*. B. Kokinov, D.C. Richardson, Th. R. Roth-Berghofer, & L. Vieu (Eds.), *Lecture Notes in Artificial Intelligence*, Vol. 4635, pp. 558–571.
- Zimmermann, A., Specht, M., & Lorenz, A. (2005). Personalization and context management. *User Modeling and User Adapted Interaction*, 15(3-4), 275–302. Springer. doi:10.1007/s11257-005-1092-2

Interactive Learning Strategies for Mobile Learning

Anthony Ralston

Abstract

The increased use of mobile devices for education can be documented over recent years in both academic and private-sector business. This chapter describes mobile learning and its relationship to interactive design and learning theories. A review of literature related to mobile learning reveals a lack of investigation pertaining to the learning processes required to this end. Much of the research discusses approaches to mobile learning in terms of methodological approaches. This gap therefore presents the opportunity for further investigation of transformative learning and self-motivation as learning theories, and of what their connection means for both learners and teachers.

Introduction

This chapter presents the results of an investigation into the connection between mobile learning (mLearning) and interactive design processes through the adaption of transformative learning and self-motivational learning. The perspective in this chapter relates to a concept in which mLearning could be closer linked to conventional learning theories. An argument can be made for the integration of both transformative learning and self-motivational learning as methodologies that can enhance the learning experience of the user in a mobile environment.

A review of current literature reveals a gap in the investigations into the correlation between recognised learning theories and knowledge as it pertains to mLearning. As noted, the research into the connection between mobile devices used in education and conventional learning theories raises questions that are integral to this chapter.

As a broad definition, Traxler (2007) summarises mLearning as activities that depend on hand-held technology (smartphones, tablets, etc.) to deliver the content, but suggests that the use of mobile devices in the education sector is still new and pedagogical approaches and evaluation of learning still require definition.

Discourses related to interactive learning all point to the prominence of a constructivist learning methodology that stems from the instructional design for learning (Dickey, 2006; Panitz, 1997; Reeves, 1997; Rieber, 1996). The foundation of a constructivist approach — namely collaborative and co-operative learning — can underpin how students interact with knowledge. Interactive learning therefore provides a vehicle for knowledge construction and transactions between the learner and the teacher. Interactivity and learning design can coexist and the concept of this approach is not limited to interactive capability of just the technology, but also includes the design of the learning experience. We are seeing in the literature an intersection of technology and learning design due in part to the advancements in technology and portable devices themselves. The aspect of interaction in this context refers to both the instructional design approach to active learning (thus, the integration of learning activities) and the capabilities of the mobile devices in terms of how elements such as video, audio and other content can be accessed by the learner. We can see that the aspects of pedagogy and technology collide in design, which Sessoms (2008, p.10) describes as “an interactive pedagogy supported by technological tools.”

The aspect of instructional design is inter-related with learning and technology when one discusses the potential of mobile devices in workplace training or formal education. The process of learning design (instructional design) can be defined as one that focuses on the plan of an educational activity meant to translate learning theory into practice as suggested by Botturi (2003). The key elements related to use of educational technology — user interaction and levels of cognitive knowledge — are normally associated with online learning instructional design. However, these concepts need to be adapted to mobile delivery and therefore require a model with which to develop the learning plan. The aspect of an instructional design model approach is discussed later in this chapter as it relates to the development of training in the area of humanitarian aid.

Peters (2009) reports that the capacity of mobile technology to deliver synchronous communication and knowledge-sharing can provide benefits to human systems. Evidence of these benefits has been reported by Ragus (2008), who found that mLearning encouraged simultaneous personal development, such as networking and socialisation, outside of normal working groups — an unexpected and positive result of the mLearning trials.

The rise in the past ten years in the technological development of mobile devices recognised as possessing educational potential has influenced pedagogy and therefore a shift in learning opportunities (Ally & Palalas, 2011; Kukulska-Hulme & Traxler, 2005; Liestøl, 2011; Peters, 2009; Rekkedal & Dye, 2009).

The humanitarian aid sector is used in this chapter as an example of one profession where the use of mobile devices for training and professional development is in its infancy and the use of these devices is rising due in part

to technology innovation and integration of mobile devices used in learning (UNESCO, 2013; West, 2012; WHO, 2011).

Humanitarian Aid Context

The humanitarian aid sector is in a growth period, and there is a shortage of aid workers and of available professional development training. A 2011 study by Enhancing Learning and Research for Humanitarian Assistance (ELRHA) revealed that although there has been improvement in learning and professional development in this sector, a gap in training opportunities remains for workers in this area (www.elrha.org/). Richardson (2006) also supports the view that, among many international non-governmental agencies, there continues to be a need for organisational learning in order to meet the ever-growing demands related to humanitarian relief globally.

As the world experiences larger, more frequent conflicts — as a result of changing demographics, growing urbanisation, civil war and other political unrest, and natural disasters — the demand for humanitarian action is expected to increase, and so too the need for trained and experienced humanitarian relief workers. However, attrition levels in this sector are as high as 25–45%, and training resources are only 1% of overall budgets per year (possibly partly accounting for the high attrition rates). The national staffs in humanitarian organisations are looking to enhance their own training and professional standing.

The use of mobile technology for training and education addresses many of the issues. As the current literature notes, a mobile device used in conjunction with an online course can create greater access and can have a positive effect with respect to training in the humanitarian aid sector. Atwell, Cook, and Ravenscroft (2009) point out, with respect to mLearning and the environment, the notion of a “Personal Learning Environment” as being “a new approach to the development of e-learning tools” (p. 20). This “PLE,” as they describe it, would contain various tools, such as Web 2.0 technologies and mobile devices, to facilitate interaction and collaboration with people and the curriculum. Quinn (2000) views mLearning as an extension of eLearning using portable computer devices, thus allowing for these devices to be used in an environment whereby collaboration spanning time and space can be achieved. O’Malley (2003) believes that mLearning transcends the traditional boundaries or fixed locations accompanied by traditional learning and therefore mobile technologies can solve issues related to humanitarian aid environments that dictate the necessity for flexible learning environments.

Research points out that in corporate training, a hand-held device is well suited to a blended learning environment where the user can review material in small sections, then refer to a more detailed version in the online course. This portable technology can influence the learning environment and thereby create an inclusive educational experience. Given current models and methods of instructional design, the mobile devices could easily be integrated into a programme that delivers curricula that humanitarian workers can access in the field.

An example of mLearning methodology is an open-source mixed-reality application framework called ARLearn, which supports mobile applications for Android smartphones (Ternier, Klemke, Kalz, Van Ulzen, & Specht, 2012). The

concept behind this pilot project involves a game-based approach for security training in the humanitarian aid sector. The logistics of engaging learners in a real-life security simulation can often involve expense, security issues, and use of weapons or equipment that can prove to be a challenge. The use of the ARLearn application is an attempt to simulate portions of the learning exercise on security training by using a mobile phone. As an alternative from the original simulation, a version was developed that applies concepts of mobile serious games and blended instructional design principles, which affects interaction between the learners and the devices themselves (Gruber, Glahn, Specht, & Koper, 2010).

The applications on the mobile phones are designed with content that is presented with audio and visual information based on trigger events. Interaction in the game is determined by location and the responses and questions the learners engage in. Additionally, the content is designed to present material in a way that provides learners with opportunities to explore their environment and collect data — all of which is common practice in humanitarian fieldwork.

In the example discussed by Ternier et al. (2012), the game simulation offers an alternative training solution that could replace aspects of role-playing in the more traditional face-to-face workshops dealing with security training. The learners, using the mobile devices, were placed in teams that represented different roles in an actual security hostage situation. There was a limited time in which to carry out the procedures, which created a highly immersive experience for the learners. This approach, using active learning, helped simulate stressful situations that demand collaboration by the participants.

As a result of this application designed to simulate a security challenge event, the participants reported that the elements of co-ordination, collaboration and reaction to stress were an important part in the design of the mobile curriculum. Of the 17 participants in this first experiment, 14 reported a positive reaction to the use of the mobile phones in this simulation. Although this is a small sample of respondents, this event was a pilot to test the methodology and the integrity of the technology and mobile devices used in this way. The ARLearn toolkit could make a positive contribution to variations in game design through its software, its ability to present real-time assessment of activities (enabling participants to experience role-playing and to change positions within the game), and its ability to create a log of events (responses and interactions) through the software that can be reviewed and assessed.

As noted previously in this chapter, the use of an instructional design model in either a classroom or eLearning delivery mode is based on traditional methods, whereas mLearning design poses a new set of aspects to be considered. Ally (2005) suggests that when designing mLearning content, a new approach needs to be taken that goes beyond established instructional design approaches. In the context of the humanitarian aid sector in Africa, Isaacs (2011) supports the use of mobile devices as a means for learning by people located in remote areas, because it increases the opportunities for access to training. A by-product of these advantages is more opportunity for social equality in terms of giving more people access to learning materials through mobile devices.

The Dick and Carey model described by Botturi (2003) is a recognised approach to classroom and eLearning design. It is a comprehensive, inter-related ten-step

process. In the case of the ARLearn pilot project, a modified model of instructional design was used that required modifications at each step in order to accommodate the mobile platform. Dick, Carey, and Carey (2011) have written recently about new approaches to learning design that take into account the integration of new technologies; constructivist approaches; design for portable devices; and measurement of the performance impact on the learner. They expand on the conventional instructional design approaches, and respond to the four main aspects of their model structure: analysis, design, development and revision. The ARLearn pilot project is an example of how an expanded approach to design — as dictated by the technology and the integration of learning theories — has an influence on the resulting curriculum design and delivery.

Knowledge Construction and Mobile Learning

The design of learning delivered by mobile devices must also take into account the construction of knowledge. Jacobson et al. (2006) suggest that the concept of epistemological knowledge is a staged developmental process, citing the works of Schommer (1990) with respect to five potential factors that contribute to epistemology (Jacobson et al., 2006):

1. *Simple Knowledge*: Knowledge consists of discrete facts. This refers to whether people perceive knowledge as separate and unrelated facts, or interrelated elements.
2. *Certain Knowledge*: Absolute knowledge exists and will eventually be known. This is the extent to which people believe that knowledge is certain and absolute, or tentative and constantly changing.
3. *Omniscient Authority*: Authorities have access to knowledge that is inaccessible to others.
4. *Innate Ability*: The ability to learn knowledge is primarily genetically determined and is not the product of achievement.
5. *Quick Learning*: Learning occurs quickly or not at all.

How are these five concepts of knowledge linked to knowledge produced in mLearning?

The common belief that mLearning and a constructivist approach are closely connected reaffirms the belief that the learner has most of the responsibility for the construction of knowledge. The acts of discussion and feedback combined with a scaffolding of knowledge lead to the opportunity for “Certain Knowledge” to be attained by the learner and community (Stefani, Mason, & Pegler, 2007). The formation of a community is not an easily attained environment and support from the teacher is necessary (Scardamalia & Bereiter, 2010).

Maton suggests that cumulative learning represents the knowledge now required in what is known as the “knowledge economy,” which is in contrast to the approaches in current education that are based on “segmented learning — where students learn a series of ideas or skills that are strongly tied to their contexts of acquisition” (2009, p. 43). A proposed model for researching the correlation between mLearning and the learning methodologies is one that could contribute to a more substantive learning experience. This model suggests that both

transformative learning and self-motivational learning theories are well suited to mLearning. Both transformative and self-motivational learning approaches, when integrated with mLearning, can offer opportunities for exploration, assessment and self-examination (Brock, 2009; Mezirow, 2002).

Transformative Learning

On its own, transformative learning (Brock, 2009; Cranton, 1994) is seen as a valued process whereby the learner can come to new knowledge or analytical connections between concepts. Combining this process with mLearning can be especially beneficial to a learner.

Transformative learning, as seen by Brock (2009), involves the realisation of a new concept and then connecting that to make a change in a person's life. As the literature shows, this process of transformation is currently lacking in mLearning.

The concept of transformative learning began with Mezirow (2002). It was described as a ten-step process whereby cognitive aspects such as exploration, assessment, self-examination and planning are part of the experience. Whether this act of transformation occurs over time or in a single moment is debatable according to the literature, but it is safe to conclude that transformative processes can yield many positive results, from group discussions and self-reflection through to autobiography (or journaling).

According to the literature, little has been done to fully replicate the ten stages of transformation, although the author notes that reflection is a key element in the transformative process. Cooper (n.d.) points out that Mezirow (1981) has strongly defended self-reflection as one of the key steps in education. For a student to achieve self-reflection and change, challenge from the instructor plays an important role in helping the student gain a greater awareness of the world around us. How one interprets the world and experiences can also be seen as part of the reflection process necessary in portfolio development (Cranton, 1994).

Christopher, Dunnagan, Duncan, and Paul (2001) link their research to Mezirow as an author of authority on transformational learning approaches. Again we see this theme of self-reflection being brought forward as the cornerstone in any transformational learning dichotomy. The premise in this learning approach is based on helping students assess their perspectives on life through educational pursuits.

Boyer, Maher, and Kirkman (2006) reported that, when one is teaching in a mobile environment, using self-directed techniques associated with transformative learning enables students to increase their ability to delve deeper into the subjects at hand. The transformative environment, when supported by an instructor in the online environment, can have positive effects on student beliefs, preconceived ideas, and ability to act on new ideas.

Transformative learning can lead a person to make fundamental changes in his or her view of the world through self-reflection. These changes can in turn change a person's life and lead to increased self-awareness and awareness of how one's previous assumptions have constrained his or her world view. The reported outcomes of transformative learning include a new sense of empowerment, increased self-confidence, greater compassion and greater connections to others.

Self-Motivational Learning

The main concept that forms the foundation of the argument here is based on the relevance of both transformational learning and self-motivational learning as theories that could be used as the vehicles that further facilitate learning in a mobile construct. With respect to self-motivation and learning, the evidence suggests that there is greater potential when mobile is partnered with motivational learning. One could agree with authors who define motivation as that which brings about greater awareness on the part of the learner.

A study by Roeser and Peck (2006) based its inquiry on the question, “What is self and what relation does self have with motivation and self-regulated learning?” They used the Basic Levels of Self (BLoS) model, as it is a more comprehensive theoretical framework that looks at persons, contexts and their dynamic interactions.

The authors also point to other literature that often frames self-regulated learning as an active participation of learning through the organisation of “emotional, cognitive, and environmental resources” (Roeser & Peck, 2006, p.121). The concept of the self is integral to research in the areas of motivation and self-regulated learning. The authors state that there are still questions as to the meaning of self. “Self” can be acquainted with motivation, but intrinsic and extrinsic motivation are often present in the learning context. There is evidence of extrinsic tendencies, and in fact the students are only motivated by the grade or outcome. To a lesser extent, intrinsic motivation arises in students and the inherent desire to learn contributes to self-motivation.

Self-assessment as it relates to self-motivation (Donham, 2010) entails being able to review personal performance and use internal criteria to determine what we need to know and what we don’t need to know. This aspect of meta-cognition and awareness is necessary for someone to attain self-assessment. The role of the teacher is integral to shaping the abilities of the students to become self-reliant and helping the students become aware of what they know and how to make adjustments for themselves. If we then apply this approach of greater teacher involvement to mLearning, motivation and the willingness for self-assessment increase dramatically so long as the infrastructure is integrated into the curriculum. The attributes that Donham (2010) points out with self-assessment and its connection to self-motivation show merit on their own, but it is only when these theories are overlaid on an mLearning model that the opportunities for elevated performance could be greater.

Usually once an assignment is completed, a student will move on to the next assignment without review or reflection by an instructor. Missing this opportunity to engage the student in self-assessment or self-motivational activities is a lost learning opportunity. The act of reviewing previous work and completed work is integral to self-motivational learning and one that can contribute to a better experience for the student.

Conclusion

This chapter highlights the connection between mLearning and interactive design processes through the adaption of transformative learning and self-motivational learning. The literature suggests several approaches in which mLearning could be

closer linked to conventional learning theories in order to produce an interactive learning experience (Dickey, 2006; Panitz, 1997; Reeves, 1997; Rieber, 1996; Sessoms, 2008).

Indeed, with respect to the current state of humanitarian training, for example, we see a gap in the current training methodologies and potential for the use of mobile technologies in this sector. Although several humanitarian agencies are exploring the opportunities that mobile devices can offer, these investigations into mLearning all point to the need for a sound methodology integrated into the design of the content (UNESCO, 2012; WHO, 2011). As highlighted in this chapter, the importance of core competencies with respect to humanitarian aid training is a sign that attention to training design through interactivity and learning theories could arguably form a methodology for the design of learning through mobile devices (Brock, 2009; Dickey, 2006; Panitz, 1997; Reeves, 1997; Rieber, 1996). The two learning theories — Transformative and Self-Motivational — included in this chapter as examples of learning theories that can co-exist with technology indicate possible solutions to the design of learning during the instructional design process.

The ARLearn mobile game approach for humanitarian workers demonstrates that there are opportunities for success when interactivity and self-motivation result in a transformation of knowledge (Ternier et al., 2012). However, the pilot project did raise questions about user acceptance of the mobile technology, the need to improve how learning is measured through assessments, and the technical infrastructure restrictions that must be accounted for in the instructional design and delivery phases.

The discussion in this chapter of a model that relates learning theories to mobile learning approaches points to potential for future research into the relationship between learning theories and mobile devices. This could yield new information about the intersections of learning design for this technology.

References

- Ally, M. (2005). Using learning theories to design instruction for mobile learning devices. In J. Attwell & C. Savill-Smith (Eds.), *Mobile Learning Anytime Everywhere*, pp. 5–8.
- Ally, M., & Palalas, A. (2011). State of mobile learning in Canada and future directions. Retrieved from www.rogersbizresources.com/files/308/Mobile_Learning_in_Canada_Final_Report_EN.pdf
- Attwell, G., Cook, J., & Ravenscroft, A. (2009). Appropriating technologies for contextual knowledge: Mobile personal learning environments. *Best Practices for the Knowledge Society. Knowledge, Learning, Development and Technology for All*, 15–25.
- Botturi, L. (2003). Instructional design and learning technology standards: An overview. *ICeF-Quaderni dell'Istituto*, 9. Retrieved from http://doc.rero.ch/lm.php?url=1000,42,6,20051011091712-KU/1_icefq09.pdf
- Boyer, N., Maher, P., & Kirkman, S. (2006). Transformative learning in online settings: The use of self-direction, metacognition, and collaborative learning. Retrieved May 24, 2013, from <http://jtd.sagepub.com.ezproxy.royalroads.ca/content/4/4/335>

- Brock, S. E. (2009). Measuring the importance of precursor steps to transformative learning. *Adult Education Quarterly*, 60(2), 122. Retrieved August 8, 2013, from <http://aeq.sagepub.com.ezproxy.royalroads.ca/content/60/2/122.full.pdf+html>
- Christopher, S., Dunnagan, T., Duncan, S., & Paul, L. (2001.). Education for self-support: Evaluating outcomes using transformative learning theory. *Family Relations*, 50(2), 134–142.
- Cooper, S. (n.d.). Jack Mezirow and Transformational Learning Theory. Retrieved November 25, 2012, from www.lifecircles-inc.com/Learningtheories/humanist/mezirow.html
- Cranton, P. (1994). JSTOR. *The Journal of Higher Education*, 65(6), 726–744. Retrieved August 8, 2013, from www.jstor.org.ezproxy.royalroads.ca/stable/2943826?seq=1
- Dick, W., Carey, L., & Carey, J. (2011). *The systematic design of instruction*. 7th ed. Pearson.
- Dickey, M. D. (2006). Game design narrative for learning: Appropriating adventure game design narrative devices and techniques for the design of interactive learning environments. *Educational Technology Research and Development*, 54(3), 245–263.
- Donham, J. (2010). Creating personal learning through self-assessment. Retrieved December 6, 2010, from <http://search.proquest.com.ezproxy.royalroads.ca/docview/224871351>
- Gruber, M., Glahn, C., Specht, M., & Koper, R. (2010). Orchestrating learning using adaptive educational designs in IMS learning design. *Sustaining TEL: From Innovation to Learning and Practice*, pp. 123–138.
- Isaacs, S. (2011). Turning on mobile learning: Illustrative initiatives and policy implications in Africa and the Middle East. Retrieved from www.unesco.org/new/en/unesco/themes/icts/m4ed/mobile-learning-resources/unescomobilelearningseries/
- Jacobson, M., So, H.-J., Teo, T., Lee, J., Pathak, S., & Lossman, H. (2006). Epistemology and learning: Impact on pedagogical practices and technology use in Singapore schools. *Computers & Education*, 55(4), 1694–1706. Retrieved November 27, 2010, from www.sciencedirect.com.ezproxy.royalroads.ca/science/article/pii/S036013151000206X
- Kukulska-Hulme, A., & Traxler, J. (2005). *Mobile learning: A handbook for educators and trainers*. Google Books. Retrieved November 7, 2012, from <http://books.google.ca/books?hl=en&lr=&id=onctUPCDt3wC&oi=fnd&pg=PR1&dq=interactive+learning+mobile+devices&ots=PVwPMBzC-g&sig=nChZjnD65cdmgpmF6z-HTANnOko#v=onepage&q=interactive%20learning%20mobile%20devices&f=false>
- Liestøl, G. (2011). Learning through situated simulations: Exploring mobile augmented reality. Retrieved September 10, 2013, from <http://net.educause.edu/ir/library/pdf/erb1101.pdf>

- Mezirow, J. (1981). A critical theory of adult learning and education. Retrieved September 21, 2013, from <http://aeq.sagepub.com.ezproxy.royalroads.ca/content/32/1/3.full.pdf+html>
- Mezirow, J. (2002). Transformative learning: Theory to practice. *New Directions for Adult and Continuing Education*, 1997(74), 5–12. Retrieved from www.dlc.riversideinnovationcentre.co.uk/wp-content/uploads/2012/10/Transformative-Learning-Mezirow-1997.pdf
- O'Malley, C. (2003, June). MOBILEarn: Guidelines for learning, teaching and tutoring in a mobile environment. Retrieved February 10, 2013, from www.mobilearn.org/index.php
- Panitz, T. (1997). Collaborative versus cooperative learning: A comparison of the two concepts which will help us understand the underlying nature of interactive learning. *Cooperative Learning and College Teaching*, 8(2), 5–7.
- Peters, K. (2009). m-Learning: Positioning educators for a mobile, connected future. *Mobile Learning*, 113. Retrieved February 10, 2013 from www.irrodl.org/index.php/irrodl/article/view/350/894
- Quinn, C. (2000, Fall). LiNE Zine – mLearning: Mobile, wireless, in-your-pocket learning. Retrieved February 10, 2013, from www.linezine.com/2.1/features/cqmmwiyp.htm
- Ragus, M. (2008). Mlearning: A future of learning. Retrieved August 2, 2013, from www.evernote.com/shard/s1/note/7127d11b-b58b-465b-9edc-5ce0132d42d9/jnxyz/mLearningScrapbook#st=p&n=7127d11b-b58b-465b-9edc-5ce0132d42d9
- Reeves, T. C. (1997). A model of the effective dimensions of interactive learning on the World Wide Web. *Proceedings of Interaktiivinen Teknologia Koulutuksessa (ITK'97)*, Hameenlinna (Finland). Retrieved from <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.136.5351&rep=rep1&type=pdf>
- Rekkedal, T., & Dye, A. (2009). Mobile distance learning with PDAs: Development and testing of pedagogical and system solutions supporting mobile distance learners. *Mobile Learning*, 51.
- Richardson, F. (2006). Meeting the demand for skilled and experienced humanitarian workers. *Development in Practice*, 16(03-04), 334–341. Retrieved September 17, 2012, from www.tandfonline.com.ezproxy.royalroads.ca/doi/full/10.1080/09614520600694950
- Rieber, L. P. (1996). Seriously considering play: Designing interactive learning environments based on the blending of microworlds, simulations, and games. *Educational Technology Research and Development*, 44(2), 43–58.
- Roeser, R., & Peck, S. (2006). An education in awareness: Self, motivation, and self-regulated learning in contemplative perspective. Retrieved April 4, 2011, from www.ncbi.nlm.nih.gov/pmc/articles/PMC2858411/
- Scardamalia, M., & Bereiter, C. (2010). A brief history of knowledge building. Retrieved December 29, 2010, from www.cjlt.ca/index.php/cjlt/article/view/574

- Schommer, M., (1990). Effects and beliefs about the nature of knowledge on comprehension. *Journal of Educational Psychology*, 82(3), 489–504. Retrieved from <http://psycnet.apa.org/journals/edu/82/3/498/>
- Sessoms, D. (2008). Interactive instruction: Creating interactive learning environments through tomorrow's teachers. *International Journal of Technology in Teaching*. Retrieved from www.sicet.org/journals/ijttl/issue0802/4_2_1_Sessoms.pdf
- Sharples, M. (2006). Big issues in mobile learning. Retrieved from http://hal.archives-ouvertes.fr/docs/00/19/02/54/PDF/Sharples_Big_Issues.pdf
- Stefani, L., Mason, R., & Pegler, C. (2007). *The educational potential of e-portfolios – supporting personal development and reflective learning*. London: Routledge.
- Ternier, S., Klemke, R., Kalz, M., Van Ulzen, P., & Specht, M. (2012). ARLearn: Augmented reality meets augmented virtuality. Retrieved from <http://lnx-hrl-075v.web.pwo.ou.nl/handle/1820/4368>
- Traxler, J. (2007). Defining, discussing and evaluating mobile learning: The moving finger writes and having writ *The International Review of Research in Open and Distance Learning*, 8(2), Article 8. Retrieved February 14, 2013, from www.irrodl.org/index.php/irrodl/article/view/346/875
- UNESCO. (2013). Mobile learning. Retrieved August 17, 2013, from www.unesco.org/new/en/unesco/themes/icts/m4ed/
- West, M. (2012). UNESCO Working Paper Series on Mobile Learning | United Nations Educational, Scientific and Cultural Organization. Retrieved September 22, 2012, from www.unesco.org/new/en/unesco/themes/icts/m4ed/mobile-learning-resources/unescomobilelearningseries/
- WHO (World Health Organization) (2001). Using ICTs and mobile devices to accelerate progress for women's children's health. Retrieved July, 19, 2013, from www.who.int/pmnch/knowledge/publications/strategybriefs/sb16_icts/en/

Mobile Learning: Location, Collaboration and Scaffolding Inquiry

Eileen Scanlon

Abstract

Critiques of mobile learning pedagogy are concerned with whether such approaches are technology led. This chapter discusses how the particular features of mobile learning can be harnessed to provide new learning opportunities in relation to collaboration, inquiry and location-based learning. Technology-supported inquiry learning is a situation rich with possibilities for collaboration. In particular, mobile learning offers new possibilities for scaffolding collaboration together with its other better-known features such as scaffolding the transfer between settings and making learning relevant by making use of the possibilities of location-based learning. These features are considered as part of mobile learning models, in particular mobile collaborative learning models.

Introduction

This chapter presents a view of mobile learning (mLearning), stressing the collaborative and location-based learning activities that are afforded in this work. Research trends in exploring this work will be considered and some recent projects treated as vignettes to illustrate how these aspects of mLearning are being played out in practice.

Mobile Learning

Sharples, Arnedillo-Sánchez, Milrad, and Vavoula (2009, p. 5) define mLearning as “the processes (personal and public) of coming to know through exploration and conversation across multiple contexts, amongst people and interactive technologies.”

Mobile technology can provide particular benefits for learners. Mobile learning often takes place outside traditional educational settings and using mobile technology can break down the barriers between formal and informal learning.

Scanlon, Jones, and Waycott (2005) identify three facets of mLearning that are particularly significant: first, learners move around physically over time and between devices; second, much learning takes place outside formal learning settings and situations; and third, much learning is ubiquitous in nature. They have also argued (Scanlon et al. 2005, p. 5) that “Mobility and portability provide a communication channel between the technological wireless network and the social, face-to-face network, and mediate the social interaction of the participants during learning situations.” So, a particular focus of interest in this chapter is the transitions between formal and informal settings that could be enabled by mobile technology. Clough, Jones, McAndrew, and Scanlon (2009) report on a survey of mobile device users who report on using their devices to support a wide range of informal learning activities, both intentional and unintentional.

There have been many attempts to mobilise or build upon learners’ interests in formal education. For inquiry learning, there is a need for learning activities to be authentic and personally relevant. Learners will be more engaged in inquiry learning if they are responsible for formulating their investigations, relevant to their own lives (see, for example, “Harnessing Technology: Next Generation Learning” [British Educational and Communications Technology Association, 2008]). This document argues for the need for a strategy for learners to be engaged and empowered through use of technology encouraging choice in learning. The U.S. National Science Foundation (2008) takes a view of cyber-learning (the use of networked computing and communications technologies to support learning) across a diverse range of contexts.

Various commentators (e.g., Charitonos, Blake, Scanlon, & Jones, 2012b; Sharples et al., 2009) have described the strengths of mLearning, stressing its potential for promoting deeper learning and reflection. In terms of learning theory, they cite social constructivist models of learning, as students interact not only with their technology but with each other, both face to face and through their technology, and connecting learning across formal and non-formal settings. Walker and Logan (2008) also write about learner engagement. This can have an impact on ownership over learning and improved self-esteem, so there is the potential for mLearning to influence these features (Jones & Issroff, 2007).

The learner can be in the classroom or lecture hall preparing for an activity, then carry out work in another location (field site, home or museum) and later reflect upon it in the classroom. Learners can continue learning beyond the compulsory setting, and connections can be made between formal and informal learning. Mobile learning creates many opportunities for informal learning (e.g., learners in their workplace or learners on the move). Mobile and location-based learning can provide opportunities for the exploration of new models of learning.

The vignettes discussed later include both formal and informal learning. Vavoula (2004) presents a typology of learning based on the presence of, and control over, the goals and the process of learning which can be used to unpack the definition of a learning setting as formal or informal. She defines *intentional formal learning* as occurring when either the goals or the process of learning, or both, are explicitly defined by a teacher or an institution. She defines *unintentional, informal learning* as occurring when the goals of learning are not specified in advance, and there is no prescribed learning process, although these can develop “on the fly” as a learning occasion arises.

Kukulska-Hulme, Sharples, Milrad, Arnedillo-Sánchez, and Vavoula (2009, p. 23) describe the key link between mLearning and context as follows:

“Context, then, is a central construct of mobile learning. It is continually created by people in interaction with other people, with their surroundings and with everyday tools. Traditional classroom learning is founded on an illusion of stability of context, by setting up a fixed location with common resources, a single teacher, and an agreed curriculum which allows a semblance of common ground to be maintained from day to day. But if these are removed, a fundamental challenge is how to form islands of temporarily stable context to enable meaning making from the flow of everyday activity.”

Location

In addition to understanding the importance of context, there is a growing interest in developing mobile technologies to enable location-based learning. One part of context when the learner is mobile is location, both in terms of where the learner is physically located and what the learner can use in the environment. Brown (2010, p. 7) writes, “The distinguishing aspect of mobile learning is the assumption that learners are continuously on the move. This is not just their physical mobility, but also how learners are active in different contexts and how frequently these might change, depending on an individual’s location.” Others emphasise the easy access to information, as mobile devices “‘afford’ real-time information whenever and wherever learners need it” (Luo, Lai, & Liang, 2010).

A number of projects have exploited the potential of location-based learning, particularly in relation to field trips or museum visits. Davies et al. (2010) in the Enabling Remote Access project studied the way in which mLearning impacted field work in their experiences of a formal educational setting for the teaching of geology in higher education. Scanlon et al. (2011) describe how the Personal Inquiry project, with the help of the nQuire software developed for use in the project, investigated the features of Urban Heat islands, with young people collecting and analysing data across different settings — including the classroom, their homes and field sites — through a scientific process of inquiry. The work involved two whole groups of year 10 Key Stage 3 classes (aged 14–15 years) who were studying geography, and their four geography teachers. Facer et al. (2004) reported on a mobile gaming experience designed to encourage the development of children’s conceptual understanding of animal behaviour, making use of physical activity supported by mobile devices in the Savannah project. Woods and Scanlon (2012) describe iSpot, a mobile tool to support the community identification of nature.

Distinctions need to be made between different aspects of mLearning related to location. One important one is that between location-based and location-aware examples. Nova, Girardin, and Dillenbourg (2005, p. 21) describe the use of location-aware devices, where the devices are aware of their geospatial position: “Overall there are two kinds of educational applications that can take advantage of positioning technologies, depending on how the location information is used. On the one hand, there are applications that track users’ or objects’ locations and display them to their partners. This is meant to support collaboration among the

group. On the other hand, knowing where the user is can lead the system to trigger specific events or to allow him/her to post messages bound to this specific location.”

This is meant to support information sharing and task-related activities. In their empirical study of this, however, Nova et al. found no difference on collaboration between those using location-aware devices and those without this facility. Their conclusion was that self-declared rather than automatic positioning might be a more informative and communicative act for learners.

The MASELTOV project (Mobile Assistance for Social Inclusion and Empowerment of Immigrants with Persuasive Learning Technologies and Social Network Services; www.maseltov.eu/) is focusing on the use of the mobile phone as a support for recent immigrants to Europe. The aim is to develop technology-rich and socially inclusive learning opportunities for immigrants within cities. One contributory factor to the social exclusion of many immigrants is underdeveloped language skills. Situated incidents create learning opportunities and provide opportunities for designers and developers of mobile tools to help create technology-enabled learning activities that are appropriate to learners’ needs for support. These support needs arise in locations such as the train station, the doctor’s surgery, the bank and the grocery store (Kukulska-Hulme et al., 2012).

Collaborative Learning

Roschelle and Teasley define collaboration as “the mutual engagement of participants in a coordinated effort to solve a problem together” (Roschelle & Teasley, 1995).

Mercer and Littleton (2007, p. 25) describe the collaboration as:

“participants are engaged in a co-ordinated, continuing attempt to solve a problem or in some other way construct common knowledge... involving a co-ordinated joint commitment to a shared goal, reciprocity, mutuality and the continual (re)negotiation of meaning.”

These researchers have elaborated the processes that need to be supported to promote successful collaborative learning. A number of researchers have analysed mLearning settings to develop a sense of how collaborative learning can take place and how tools can scaffold such learning. For example, Zurita and Nussbaum have, in a number of studies (2004, 2005), investigated collaborative activities, analysed with and without technological support. They looked in particular at math and language activities for 6- and 7-year-old children in order to assess the impact of mLearning on collaboration.

Rogers and Price (2008) review the role of mobile devices in supporting collaborative inquiry in a particular outdoor setting. They use as their example the Ambient Wood project. Children (aged 11–12) carried out inquiries, in a digitally connected (ambient) wood. Information was presented on mobile devices triggered by the children’s activities and location. They successfully used different tools, such as sensors and mobiles, physical exploration of the setting (the wood), and collaboration through face-to-face talking to each other and the facilitator. Coughlan, Adams, Rogers, and Davies (2011) and Coughlan et al. (2012) in the Out There in Here project have extended their consideration of technology support for field trips, working with a combination of mobile tools

and co-ordinating tools in a “mission control” setting, providing a rich ecology for collaborative working.

Vignettes

The three examples below of mLearning that makes use of collaborative learning and location-based learning illustrate the features mentioned above.

Microclimates Vignette

The Personal Inquiry project (www.pi-project.ac.uk) funded by ESRC TEL researched support for young people in conducting personal inquiry learning in school and home settings using mobile technology. Personal inquiry learning engages young people with learning by using topics relevant to the community, the environment and the young people themselves. The project demonstrated how to engage young people with mobile tools to support their learning, and developed an inquiry learning framework to scaffold their learning.

One example taken from the Personal Inquiry project (Littleton & Kerawalla, 2012) describes children working on a microclimates activity. The microclimates project involved children (aged 11–12) and their teachers in one of the project’s partner schools, as part of their geography lessons. The children study the topic of microclimates and, as part of that, they conduct an investigation into microclimates in the school. They start off by deciding the focus of their inquiry. In this project, the children chose to investigate a number of questions such as where is the best place in the school grounds to put a bench, where is the best place to fly a kite or which is the best location to plant a flower garden. They made a hypothesis to be tested by making measurements. They planned their investigation taking into consideration what equipment they had and what measurements they would make in which locations. They had a range of sensors, including temperature sensors, anemometers, humidity sensors, compasses and light-level assessment tools (also measured by cloud cover inspection). Then they went outside in groups, collected their data, returned to the classroom to make sense of what they had, and wrote up their report. All this activity was co-ordinated by a toolkit they have available on the ultra-mobile computer that supports them in their inquiry. Further aspects of the project are discussed in Littleton, Scanlon, and Sharples (2012).

Geocaching Vignette

Clough (2010) conducted a study of a geocaching community — that is, an online community that relies upon rapidly evolving social and location-aware mobile technologies. Members used social networking tools and online and offline community resources to learn about the geology, geography and history of their local and other areas. This community uses mobile and social technologies to blur the boundaries between the virtual spaces of the Internet and the physical spaces that surround them, so this example makes use of both the collaborative learning and location-aware properties of mobile devices. Geocaching community members create shared resources for others to find and support community activities by contributing to the logbook of caches as they find them, extending community knowledge.

Clough (2010, pp. 36 and 39) writes:

“Geocachers form a geographically distributed community who use mobile and Web 2.0 technologies to coordinate and document their activities, linking the collaborative virtual spaces of the internet with location-specific physical spaces. Geocaching is essentially a form of GPS guided treasure hunt in which participants (usually in groups) hide Geocaches and provide their location coordinates via a cache description on the website so that others can use GPS devices to guide themselves to the cache location.... Participation in the community activities, initially by using shared resources to seek out Geocaches, and subsequently by contributing to the community resources by hiding new Geocaches for others to find, has revealed how mobile and Web 2.0 technologies can be used to create engaging and meaningful learning opportunities that focus on physical location.”

Museum Vignette

Charitonos, Blake, Scanlon, and Jones (2012a, 2012b) investigated the use of social and mobile technologies to enhance the experience of a group of learners on a museum visit. The participants were a Year 9 History class (13–14 years old) in a secondary school in Milton Keynes visiting the Museum of London. Such school trips are an important means of introducing young people to museum collections and can have long-term impacts on their learning and perceptions of museums. Considerable classroom preparation was done. Then, Twitter was used to impact the social dynamics of the trip during and after the visit to the museum. A combination of observational data, the visit’s Twitter stream and interviews conducted after the visit were used to assess the contribution of mLearning tools to the learning and meaning-making. The contribution to meaning-making was found to be significant. The students engaged with their environment and each other through “socially made and culturally specific resources, in ways that arise out of their interests” (Kress, 2011, p. 57). Students worked in small groups during the visit to the museum and shared their visit within and across groups. The authors stress the process of student artefact co-creation in these collaborative activities. It helped the students, to a certain extent, to engage and negotiate with the museum content and make sense of their experiences and their learning.

Discussion

Each of these examples provides an illustration of particular features of mLearning. In the microclimates example, the mobile tools provided children with scaffolded support to conduct fieldwork outdoors in groups. The investigation they planned and the data they collected was location based and tagged to the location in which it was collected. The mobile tool enabled seamless transition between the indoor classroom and outdoor data collection. In the geocaching example, the collaboration was more extended over time with others who were not co-present but were involved in the design and planting of the geocache. In the museum example, the use of Twitter as a mobile tool allowed significant development of the meaning-making themes worked on by small groups during the visit. The vignette features are summarised in Table 7.1.

Table 7.1: Features of mLearning vignettes

Project theme	Setting	Key elements	Collaborative learning model	Use of location
Inquiry Littleton et al. (2012)	Classroom to outdoors	Groups Significant places	Orchestration	Physical location tagged to experimental readings Location-based Location-aware
Geocaching Clough (2010)	Outdoors	Community support for location-based learning	Socio-cultural	Integral Location-based Location-aware
Social Networking Charitonos et al. (2012a, 2012b)	Classrooms to museum	Artefact creation	Meaning-making	Crossing contexts of classroom and museum Location-based

In these vignettes, the use of mobile devices allows location to play a role in the learning activities. FitzGerald et al. (2012, p. 7) describe how “over recent years the capabilities of location-aware technologies has dramatically increased. Combining GPS and digital compass technologies can provide a basic functionality for locating someone holding a device and computing their orientation within that environment.” They discuss the possibilities of augmented reality on mobile devices as making use of these capabilities and the new educational scenarios created when they are embedded in mobile devices in outdoor settings.

Conclusion

This chapter has reviewed some of the literature on mLearning and, in particular, features of mLearning that allow for collaborative and location-based learning. Three vignettes of mLearning were discussed.

The most complete attempt to capture the theoretical approaches made to understand mLearning is that produced by Sharples, Taylor, and Vavoula (2007) and Taylor et al. (2006). In their theory of mLearning drawing from work on a MobiLearn, a project funded by the European Commission, they extended Engeström’s activity theory (Engeström, 1987) to consider the interactions between people and technology enabled by mLearning. Recently, in the computer-supported collaborative learning community, attempts have been made to capture the particular interplay of mLearning and collaboration (Chen, Kao, & Sheu, 2003; Lai et al., 2007; Moe, 2009; Zurita, Nussbaum, & Sharples, 2003). As yet, however, this has not been combined with aspects of mLearning related to location to provide an integrated framework.

One attempt to provide this integrated framework is in progress. In the MASELTOV project described above, a first version of an incidental learning framework has been produced to analyse mobile incidental learning and to facilitate the communication of learning design (Kukulska-Hulme et al., 2012). The framework consists of the place the incident occurs, the tasks the learner is carrying out, the tools the learner uses, the social support that the learner makes use of, the learning outcomes to be achieved, and the time the incidental learning occurs. Both place and time can contain contextual information (Sprake & Rogers,

2011), and social support can include collaborative activity. So, as this project continues and the framework is iterated and tested against the mobile system developed, we will be able to assess its utility.

Acknowledgements

My thanks are due to Mike Sharples and the other members of the Personal Inquiry project for their inspiration over the last few years; to Canan Blake for comments on drafts of this chapter; and to Gill Clough, Koula Charitonos and Jenny Waycott for their innovative approaches to the investigation of mLearning.

References

- British Educational and Communications Technology Association. (2008). *Harnessing technology: Next generation learning*. Final Report, BECTA, UK.
- Brown, E. (2010). *Education in the Wild: Contextual and location-based mobile learning in action*. Report from the STELLAR Alpine Rendez-Vous Workshop Series. Nottingham, UK: Learning Sciences Research Institute, University of Nottingham.
- Charitonos, K., Blake, C., Scanlon, E., & Jones, A. (2012a). Museum learning via social and mobile technologies: (How) can online interactions enhance the visitor experience? *British Journal of Educational Technology*, 43(5), 802–819.
- Charitonos, K., Blake, C., Scanlon, E. & Jones, A. (2012b). Trajectories of learning across museums and classrooms. *The Transformative Museum*, 22–25 May 2012, Roskilde, Denmark. Retrieved February 17, 2013, from www.dreamconference.dk/?page_id=1014
- Chen, Y. S., Kao, T. C., & Sheu J. P. (2003). A mobile learning system for scaffolding bird watching learning. *Journal of Computer Assisted Learning* 19, 347–359.
- Clough, G. (2010). *Geolearners: Location-based informal learning with mobile and social technologies*. IEEE Transactions on Learning Technologies, September, 33–44.
- Clough, G., Jones, A., McAndrew, P., & Scanlon, E. (2009). Informal learning evidence in online communities of mobile device enthusiasts. In M. Ally (Ed.), *Mobile learning: Transforming the delivery of education and training. Issues in distance education* (99–112). Athabasca University Press.
- Coughlan, T., Adams, A., Rogers, Y., & Davies, S. (2011). *Enabling live dialogic and collaborative learning between field and indoor contexts*. Paper presented at the 25th BCS Conference on Human Computer Interaction, 4–8 July 2011, Newcastle Upon Tyne, UK.
- Coughlan, T., Collins, T., Adams, A., Rogers, Y., Haya, P., & Martin, E. (2012). The conceptual framing, design and evaluation of device ecologies for collaborative activities. *International Journal of Human Computer Studies*, 70(10) 765–779.

- Davies, S., Collins, T., Gaved, M., Bartlett, J., Valentine, C., & McCann, L. (2010). Enabling remote activity: Using mobile technology for remote participation in geoscience fieldwork. In *Proceedings of the European Geosciences Union General Assembly 2010* (EGU 2010), 2–7 May 2010, Vienna, Austria.
- DfES (2005). *Harnessing technology: Transforming learning and Children's Services*. Retrieved November 2008 from www.dcsf.gov.uk/publications/e-strategy/docs/e-strategy.pdf
- Engeström, Y. (1987). *Learning by expanding: An activity-theoretical approach to developmental research*. Helsinki: Orienta-Konsultit.
- Facer, K., Joiner, R., Stanton, D., Reid, J., Hull, R., & Kirk, D. (2004). Savannah: Mobile gaming and learning? *Journal of Computer Assisted Learning*, 20(6), 399–409.
- FitzGerald, E. (2012). Creating user-generated content for location-based learning: An authoring framework. *Journal of Computer Assisted Learning*, 28(3), pp. 195–207.
- FitzGerald, E., Adams, A., Ferguson, R., Gaved, M., Mor, Y., & Thomas, R. (2012). Augmented reality and mobile learning: The state of the art. In *Proceedings of the 11th World Conference on Mobile and Contextual Learning* (mLearn 2012), 16–18 October 2012, Helsinki, Finland.
- Jones, A., & Issroff, K. (2007). Motivation and mobile devices: Exploring the role of appropriation and coping strategies. *Research in Learning Technology*, 15(3) 247–258.
- Kress, G. (2011). What is a mode? In C. Jewitt (Ed.), *The Routledge handbook of multimodal analysis* (pp. 54–67). London: Routledge.
- Kukulska-Hulme, A., Gaved, M., Brasher, A., Jones, A., Scanlon, E., & Paletta, L. (2012). Designing for inclusion through incidental language learning. *Proceedings of ICT4All Conference on Language Learning*, November 2012, Florence.
- Kukulska-Hulme, A., Sharples, M., Milrad, M., Arnedillo-Sánchez, I., & Vavoula, G. (2009). Innovation in mobile learning: A European perspective. *International Journal of Mobile and Blended Learning*, 1(1), 13–35.
- Lai, C. H., Yang, J. C., Chen, F. C., Ho, C. W., & Chan, T. W. (2007). Affordances of mobile technologies for experiential learning: The interplay of technology and pedagogical practices. *Journal of Computer Assisted Learning*, 23(4), 326–333.
- Littleton, K., & Kerawalla, L. (2012). Trajectories of inquiry learning. In K. Littleton, E. Scanlon, & M. Sharples (Eds.). *Orchestrating inquiry learning* (pp. 31–47). Oxford: Routledge.
- Littleton, K., Scanlon, E., & Sharples, M. (Eds.) (2012). *Orchestrating inquiry learning*. Oxford: Routledge.
- Luo, P., Yang, S., Lai, C., & Liang, J. (2010). Development and evaluation of mobile learning system for collaborative learning, *UbiLearn 2010*. [Online] Available at: <http://nutnr.lib.nutn.edu.tw/handle/987654321/8109>

- Mercer, N., & Littleton, K. (2007). *Dialogue and the development of children's thinking: A socio-cultural approach*. London and New York: Routledge.
- Moe, S. P. (2009). *Design and evaluation of a user centric information systems: Enhancing student life with mobile computing* (Master's thesis). Norwegian University of Science and Technology.
- National Science Foundation (2008). Fostering learning in the networked world: The cyber-learning opportunity and challenge. Retrieved November 2012 from www.nsf.gov/pubs/2008/nsf08204/nsf08204.pdf.
- Nova, N., Girardin, F., & Dillenbourg, P. (2005). "Location is not enough!": An empirical study of location-awareness in mobile collaboration. *Wireless and mobile technologies in education, 2005* (WMTE 2005) (pp. 21–28). IEEE International Workshop, 28–30 November 2005. doi: 10.1109/WMTE.2005.2
- Rogers, Y., & Price, S. (2008). The role of mobile devices in facilitating collaborative inquiry in situ. *Research and Practice in Technology Enhanced Learning*, 3(3), 209–229.
- Roschelle, J., & Teasley, S. (1995). The construction of shared knowledge in collaborative problem solving. In C. E. O'Malley (Ed.), *Computer supported collaborative learning* (pp. 69–97). Heidelberg: Springer-Verlag.
- Scanlon, E. (2011). Analyzing productive interactions in CSCL: Collaborations, computers and contradictions. In S. Puntambekar, G. Erkens, & C. E. Hmelo-Silver (Eds.), *Analyzing interactions in CSCL: Methods, approaches and issues* (pp. 319–339). Computer-Supported Collaborative Learning Series, 12 (Part 3). Springer.
- Scanlon, E., Blake, C., Twiner, A., Collins, T., Jones, A., & Kerawalla, L. (2011). Collaboration in communities of inquirers: An example from a geography field trip. In *Proceedings of 9th International Computer-Supported Collaborative Learning Conference*, 4–8 July 2011, Hong Kong.
- Scanlon, E., Jones, A., & Waycott, J. (2005). Mobile technologies: Prospects for their use in learning in informal science settings. *Journal of Interactive Media in Education*, 21(5), 1–17.
- Sharples, M., Arnedillo-Sánchez, I., Milrad, M., & Vavoula, G. (2009). Mobile learning. *Technology-Enhanced Learning*, 233–249.
- Sharples, M., Taylor, J., & Vavoula, G. (2007). A theory of learning for the mobile age. In R. Andrews & C. Haythornthwaite (Eds.), *The Sage handbook of e-learning research* (pp. 221–247). London, UK: Sage.
- Sprake, J., & Rogers, P. (2011). Located lexicon: A project that explores how user generated content describes place. *Future Learning Spaces*, 219–234. ISSN 1799-4853.
- Sutch, D., & Sprake, J. (2006). Mudlarking in Deptford: A new kind of guided tour empowering students to interact with the environment. Accessed from www.futurelab.org.uk/projects/mudlarking-in-deptford/details/
- Taylor, J., Sharples, M., O'Malley, C., Vavoula, G., & Waycott, J. (2006). Towards a task model for mobile learning: A dialectical approach. *International Journal of Learning Technology*, 2(2/3)138–158.

- Vavoula, G.N. (2004). *KLeOS: A knowledge and learning organisation system in support of lifelong learning*. Electronic, Electrical and Computer Engineering: University of Birmingham.
- Walker, L., & Logan, A. (2008). *Learner engagement*. NESTA Futurelab. Retrieved November 2012 from www.futurelab.org.uk/resources/documents/other_research_reports/Learner_Engagement.pdf
- Waycott, J., Jones, A., & Scanlon, E. (2005). An activity theory framework for analyzing PDAs as lifelong learning tools. *Learning, Media and Technologies*, 30(2) 107–130.
- Woods, W., & Scanlon, E. (2012). iSpot Mobile: A natural history participatory science application. In *Proceedings of Mlearn 2012*, 15–16 October 2012, Helsinki, Finland.
- Zurita, G., & Nussbaum, M. (2005). A comparative usability study of two different technologies in a specific domain with children. In *Proceedings of the 3rd Annual Hawaii International Conference on Education*, Honolulu, Hawaii.
- Zurita, G., & Nussbaum, M. (2004). Computer supported collaborative learning using wirelessly interconnected handhelds computers. *Computers and Education*, 42, 289–314.
- Zurita, G., Nussbaum, M., & Sharples, M. (2003). Encouraging face-to-face collaborative learning through the use of handheld computers in the classroom. In *Mobile HCI 2003* (pp. 193–208). Udine, Italy: Springer-Verlag.

PART

II

Implementing Mobile Learning

Open Formats for Mobile Learning

Geoff Stead

Abstract

Successful mobile learning (mLearning) initiatives are surprisingly diverse. Some prescribe standardised devices and applications to a cohort of learners while others adopt a Bring Your Own Device (BYOD) strategy, using a mesh of different devices, apps and content. Some weave tools into existing learning scenarios, while others use mLearning to create new ones. This diversity creates a challenge for those evaluating emerging technologies as tools for learning (how to identify the specific impact that one piece of technology has on the learning process and outcomes), as well as those hoping to transition good mobile content from one learning scenario to another.

Mobile learning frameworks like FRAME highlight this inter-relationship, showing how the learning outcomes emerge from an interaction between the technology, the learner and the context. However, evaluating mLearning experiences can be difficult because of the many variables.

This chapter builds on research funded by the U.S. government in the Mobile Learning Environment (MoLE) project, which explored the different technologies that underpin most mLearning content, trying to answer the question “Which formats and technologies are best for simplifying the process of moving good mobile learning between different platforms?” The project team researched and tested the most relevant guidelines and standards, as well as building many different prototypes, culminating in a 24-nation live trial on tablets, media players and smartphones. The optimal solution was found to be a “mesh” of different technical approaches, bridging some of the gaps between mobile platforms, and improving the portability of the learning apps that run on them.

The standards and technical approach proposed in this chapter form the basis of the open source OMLET framework (Open Mobile Learning Toolkit). OMLET

is a core component of several commercial deployments in the U.S. and the UK. Content suppliers are starting to adopt these standards to build new mLearning content. Most significantly, the U.S. government JKO (Joint Knowledge Online) platform has adopted them for all future content that they commission.

Introduction

Mobile learning (mLearning) offers many potential benefits to work-based learners. These benefits include the ability to engage in ongoing, professional development during “stolen moments” anytime and anywhere; blending together access to reference materials, performance support and professional development; and 24-hour “just in time” support for immediate needs — all available through the learners’ familiar simplicity of their own, personal smartphone. The benefits for employers are also clear, such as an engaged and improving workforce, quicker methods for sharing time-critical data, enhanced access to feedback from employees, and reduced costs of downtime caused by attendance on conventional courses.

These are the accepted wisdoms, but what is really happening? A recent Good Technology report into Bring Your Own Device (BYOD); using employees own mobile devices in the workplace) found that over 75% of employers are already supporting mobile access to the workplace, or plan to within the next year (Good Technology, 2012). Studies looking at mLearning adoption found that a surprising number of employers were planning to use these same devices for accessing learning and training. For example, ASTD estimated 28% in their research paper (ASTD, 2012).

Several studies found that the main barriers to wider corporate adoption were technical (ASTD, 2012; Towards Maturity, 2013). In BYOD scenarios, some devices will be more fit-for-purpose than others, leading to potential lack of parity amongst learners. Supporting a diverse range of devices safely and fairly requires:

- addressing challenges in the deploying, sharing and managing of apps and content (operational),
- managing risks to confidentiality and Intellectual Property Rights (security of data),
- managing access to materials both on- and off-line (variations in Internet access and device capacity), and
- meaningfully tracking usage and measuring progress (analytics/tracking).

As an investment in the development of effective practice in mLearning, the U.S. government sponsored a two-year technology research project to explore the technical challenges involved in deploying mLearning as a core element of its mainstream eLearning delivery. The Mobile Learning Environment project (MoLE; www.mole-project.net) developed sample content, tools and platforms for mobile, work-based learners involved in humanitarian and disaster relief work. These were deployed under the name Global MedAid, a mobile app for both iOS and Android that was trialled in 24 nations by 270 learners using several language versions (Figure 8.1).

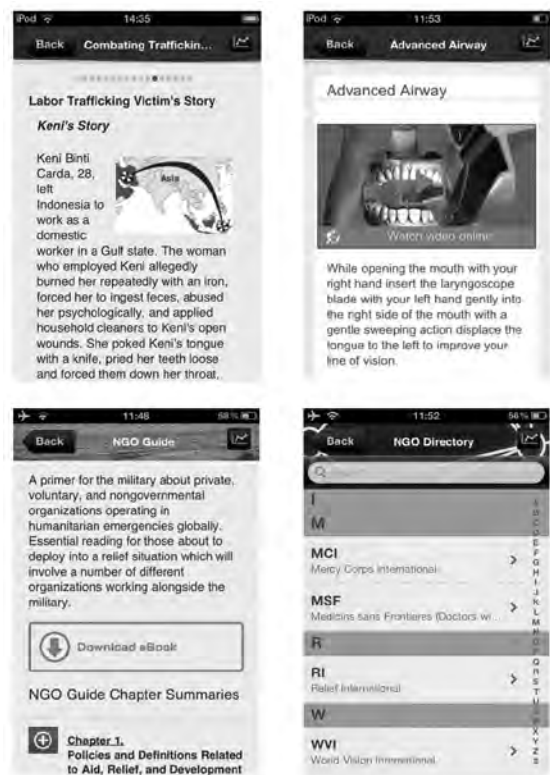
The technology team carried out practical research and prototype development to explore the underpinning technologies required to deliver meaningful mLearning

tools and content to a massively diverse user group whose common feature was that they were all very mobile, work-based learners. It became clear that they all shared certain specific requirements of mLearning: they needed small, easy-to-access nuggets of learning mixed with support tools that were quick to locate and easy to use across a wide range of devices. Work-based learning tends to be multi-episodic, informal and just-in-time. Although mobile devices have been shown to foster situated approaches to learning in and across work contexts (Pachler, Pimmer, & Seipold, 2011), the employers of these particular learners had previously forbidden this. In addition, the identified user group was likely to have only occasional access to the Internet, and needed a diverse mix of resources including:

- compliance-based “courses” that require tracking,
- video interviews with domain experts for guidance and support,
- active “checklists” as performance support tools,
- published e-books and other existing resources, and
- mobile reference tools and look-up charts.

Figure 8.1 shows a selection of these screens from the Global MedAid app.

Figure 8.1: Range of different types of content from the Global MedAid app.



The research team worked within this range of resource types, exploring different technical approaches that would allow them to “travel well” between platforms. This was done in reference to traditional eLearning standards, emerging Web, and mobile media trends. The final combination of frameworks and technical standards adopted worked well on a diverse range of devices, and can be used for

a wide range of work-based mobile learners. This mesh of standards, though still evolving, has already been adopted by the leading U.S. government eLearning platform as part of a move to mobile. This chapter sets out the basic foundations, shares technical lessons learned, and outlines the proposed open formats.

Technology as an Integral Dimension

Successful mLearning is a complex blend of the learner's own skills, the affordances of the device, the appropriateness of the content, the mix of media, the context of the learning, the fluidity of the software, and the performance of the mobile app itself (Koole 2009; Stead 2012a, 2102b). It is a vast subject area, so this chapter focuses on the technologies that support the links between elements of the overall blend. It looks at content issues (e.g., data formats); the technologies required to create interactivities inside the content; interface design and how this differs across mobile platforms; protocols for sharing packages of mobile content between phones; and mechanisms to share tracking data with learning platforms.

In evaluating mLearning content from this perspective, it is beneficial to include as many of the dimensions as possible, both technical and non-technical. Examples include:

- ease of navigation,
- quality of interactivities and appropriateness for the device in question,
- “findability” of content on a specific device,
- range of supported devices, and
- effort required to move content onto a new mobile device.

These provide challenges for all stakeholders. Some typical dilemmas for mobile developers include:

- For optimum user experience, an app should be developed to target a specific mobile platform (e.g., iOS), but for maximum portability of the content it should not.
- For maximum portability of content, the best technical solution is to use a Web app (hosted online), but this excludes all the best phone features (native menus, camera, GPS, other apps, etc.).
- For the best mLearning experience, users need to be able to work offline, but for integration with traditional eLearning systems, the information needs to sync online.

The solution to these technical dilemmas is to recognise the connections between content, interactivity, the app features and the type of learning itself. The role of the technologist is to try to extract open, re-useable formats and standards that allow these different dimensions to travel well across and between different learners and different platforms.

Good practice in traditional eLearning does not assume that one course or programme will provide comprehensive, one-size-fits-all coverage, despite the claims of some providers. The same applies to good mLearning models. It is unrealistic to expect one single app or course to provide the entire breadth of learning required for any given domain area. The assumption is that a small

amount of well-contextualised and focused information is more effective for learning than a large-scale, more ambitious and conventionally structured programme; and that part of the benefit of mobile access is being able to jump into small nuggets of relevant and sometimes personalised information (see Sharples, Taylor, & Vavoula [2005] for a typical example, or Smith [2011] on context awareness). This makes it all the more relevant to support the development of larger pools of small learning nuggets that can be seamlessly assembled in different combinations, for different learners, on different devices, and with links leading outside the mobile world where needed.

Technical Approaches to Sharing Mobile Learning

For technologists developing mLearning apps that they would like to share between multiple device types and multiple potential authors, there are four main approaches to technical development:

- Open apps – Involves software techniques that enable developers to create an app that runs on different mobile phone platforms in a single build (cross-platform development)
- Open content/content formats – Allows individual pieces of content to display on multiple devices, using industry standard “players” (e.g., e-book readers) or with native device support (e.g., audio and video files)
- Open content with embedded interactivity – A hybrid between the above two approaches, and is the ideal scenario for learning interactivities, because it combines content with appropriate learning interactions (e.g., a Web app: HTML+ JavaScript)
- Open protocols, and formats to encourage sharing – Involves both the sharing of content and the sharing of tracking, progress and messaging between applications

All of these were explored during the technical development of the MoLE project, and a combination of the three was found to be the most successful. Details about the optimal formats are described below.

Open Apps: Cross-Platform Application Development

Despite the efforts of many technology experts and enthusiasts engaging in this area, there remains no perfect solution to this challenge of developing a mobile application that will work perfectly on all devices. Each distinct approach has its own merits, and disadvantages, with many mobile developers still believing that there is no viable alternative to native coding for each device type. At the highest level, the main approaches include:

- cross-compilation (code once, but compile multiple times, for different devices),
- mobile Web apps (the app runs in the mobile browser), and
- hybrid Web app (native “player” app, with Web app type content).

These are true of all mobile development, but an open mLearning solution imposes some additional requirements that help to narrow the alternatives:

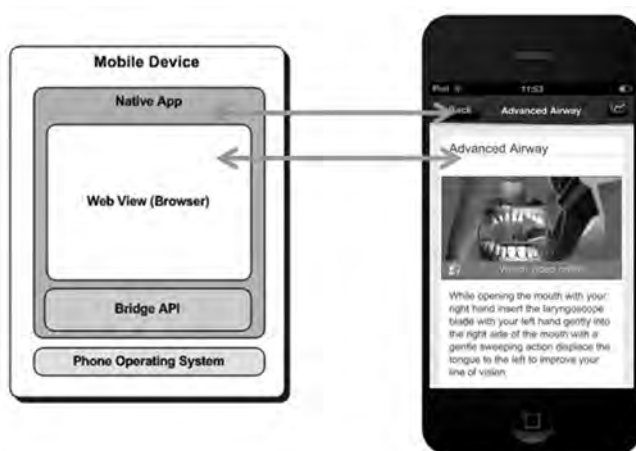
- separation between content (easy to make and share) and platform (needing technical expertise);

- provision of many content types needing embedded interactivity — presentation media alone is not enough;
- offline access to content, but online syncing and tracking;
- deeper integration with underlying mobile features (e.g., GPS, sync, camera, microphone, e-book reader app); and
- maintenance of a familiar user interface, appropriate for whichever device the learner was using.

The project team did a detailed analysis of these different technical approaches (Hartmann & Stead, 2011), building several prototypes and testing performance before finally deciding on a variation of the final hybrid approach that offered a clear split between content and platform. Content can be made by anyone, and is stored either in a generic, mobile format (like EPUB or MP3) or as browser-friendly HTML5. The content is managed by a hand-coded “native” app that provides menus, settings and any other system-level functionality. The open-source PhoneGap framework (www.phonegap.com) is a popular example of this approach. The project team used PhoneGap as the basic building block, adding custom native extensions to add learning-specific functionality. This allowed for a native app, with opening menus hand-coded for each platform but embedded content to be created in a platform-agnostic manner. The bridge between these two layers was managed by PhoneGap and additional plugins developed by the project.

Figure 8.2 shows a snapshot of this in action. The content page shows a video launch page. The black bar on the top is natively coded for iOS. The Android equivalent looks subtly different, with no back button and access to a system menu. The main page itself is created in HTML and is identical on all platforms. When the user clicks the link to watch the video, this can be managed in-page (HTML5) or directly by the app which has performance benefits (launching the video in the native video player).

Figure 8.2: App architecture mapped against a real page from the Global MedAid app.



Open Content: Formats for Mobile Media

The mobile Web and digital media sharing have largely driven the current standards for compressing and sharing mobile media files (W3C standards; see Hazael-Massieux, 2012). Some define the file format itself, and others define how files relate to one another. To maximise the future use of mLearning, these generic mobile formats should be used if at all possible for all new content development.

The basic design principles for looking at content formats were:

- Media should be formatted for cross-platform playback, avoiding platform-specific formats in favour of open ones.
- Individual media files should be optimised for mobile (compressed).
- As much of the interactivity as possible should be delivered via browser-supported technologies. In most cases, this means using HTML5, JavaScript and associated Web formats.
- HTML5 content should be designed to flow, dynamically adapting layout between landscape and portrait, as well as to a range of screen sizes.

Within these broad guiding principles, the project team tested individual media types in an effort to find the optimum format for each one. Video is a good example, since despite standardisation of higher-level formats, not all codecs work on all devices. The team found the optimum formats currently available for each media element to be as follows:

Video and audio – Although there are many different audio and video formats available, most devices (such as the iPod) and programmes (such as Windows Media Player) will only take a few specific formats. An AVI or WMV movie will not play on an iPod, for example, without being converted into an MP4 file. However, there are a few formats that have close-to-universal support from smartphones, and should be used to ensure reusability:

- Audio: The two formats with the broadest support across mobile devices are MP3 (<http://en.wikipedia.org/wiki/MP3>) and its successor, AAC (http://en.wikipedia.org/wiki/Advanced_Audio_Coding).
- Video: MPEG-4 has close-to-global support on mobile devices, specifically the H.264/AVC standard (<http://en.wikipedia.org/wiki/H.264>). MPEG-4 itself is a container format, meaning that it can contain many different formats within it, but sticking with H.264/AVC will ensure portability.

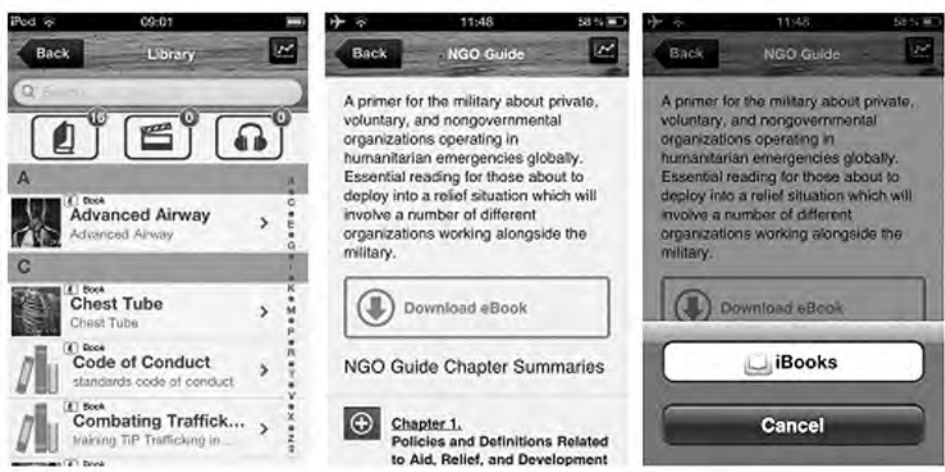
E-books – Where a large amount of text is required, e-books proved an ideal format for sharing and packaging downloadable material. There are many e-book types available, but for maximum coverage the key formats are:

- EPUB: This is rapidly becoming the gold standard. It works on almost all e-book readers (except some Kindles and older phones).
- MobiPocket (.mobi): This is the gold standard for mobile phone based readers. It is not dissimilar to EPUB (some people treat it as an earlier format of EPUB).
- AZW (Amazon's Kindle format): This is exactly the same as .mobi but renamed (can be .mobi, .prc or .azw).

(For more information, see http://en.wikipedia.org/wiki/Comparison_of_e-book_formats.)

All three of these are based on XHTML/CSS (similar to a package of webpages), which means that they may not look the same on all devices. E-book readers themselves are very much like Web browsers but with very limited layout controls. Most only use their own in-built fonts, ignoring other instructions that may be included in the file format. There are several enhanced EPUB formats (like EPUB3 and Apple's new proprietary extensions to EPUB), but these have very little support on smaller devices. See Figure 8.3.

Figure 8.3: Sample workflow integrating a native search, an HTML summary page, and integration with an external e-book reader.



Another option is PDF (portable document format). All modern smartphones can load PDF files directly. This is good (for portability) but very bad for optimised legibility. Unlike the first three formats, the layout is fixed. The page does not reflow to fit the screen. The fonts do not properly resize. This makes for tricky reading.

Feedback from learners reading PDF on their devices was not good. Where possible, it is advised to use EPUB or other flowable formats instead of PDF (EPUB can be easily converted to .mobi and .azw to reach wider devices).

Open Content: Formats for Embedding Mobile Interactivity

Learning content is rarely just “media.” Interactivity is often added to support deeper understanding through the creation of an on-screen activity, or even building a fully functioning learning tool. Use of HTML5 enables all of these options to be supported as both the content and the interactivity travel together.

Another major advantage of the “Hybrid Mobile Web App” approach taken in the project is that, by separating content from platform and allowing the content to be rendered (displayed) in an embedded Web browser inside the app, the content itself can be developed to run equally well on any supported mobile device. It also allows the creation of a rich ecosystem of content. Anything that will work as a Web app can work as mLearning content.

HTML5 as an ideal format – The project defined Mobile Learning Objects (or micro-courses) as self-contained HTML packages not unlike SCORM (an

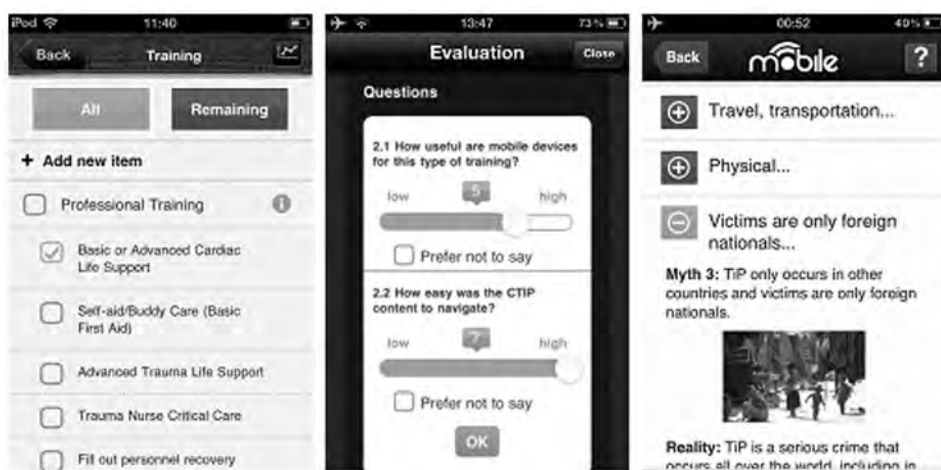
eLearning standard, www.adlnet.gov/capabilities/scorm) or the W3C Widget definition (www.w3.org/TR/widgets). Functionally, this approach is open-ended, allowing developers the freedom to use XHTML, HTML5, and any combinations of CSS and JavaScript to support their content and add richer functionalities.

Any functionality supported by the local Web view (Web browser) is available to course developers. Two different technical approaches are available (see Figure 8.4):

1. Pure HTML, generic JavaScript: By using only HTML and JavaScript with 100% browser support, you can ensure that your content is truly “develop once, play on all devices,” but you are limited in the richness of the interactivity.
2. Optimised for different devices: To exploit a wider range of device-specific features, adaptive JavaScript calls can be created that detect the browser type and render optimised pages for each.

Good examples using the second option can be built using JQueryMobile (<http://jquerymobile.com>) or Sencha Touch (www.sencha.com/products/touch), or perhaps by using WebKit-specific JavaScript calls (www.webkit.org) to achieve animated effects. If developers use these approaches, they can develop richer interactivities, but they need added skills to ensure proper playback across all devices and graceful degradation where these features are not supported.

Figure 8.4: Sample content screens developed using HTML and JavaScript.



These are some of the technological approaches, but to create truly engaging mobile content, significant effort also goes into design and interactivity. Many of the guidelines for making good mobile websites are useful here, though not all the advice is relevant for a downloaded mLearning package.

Useful reference sites for design include:

- Jakob Nielsen’s advice on “designing for mobile: www.useit.com/alertbox/mobile-vs-full-sites.html
- Design advice from These Days Labs: <http://labs.thesedays.com/blog/2010/07/16/10-tips-for-designing-mobile-websites>

Some of the key style guides to consider when using this approach are:

- cut features, to eliminate things that are not core to the mobile use case (requires learning design skills);
- cut content, to reduce word count and defer secondary information to secondary pages (requires editorial skills);
- design with a fluid layout to cope with different screen sizes (minimum width: 320px);
- use of CSS3 for visual effects (rather than older Web-based approaches, like image slices); and
- enlarged interface elements to accommodate “fat fingers” (suggested: 44x44px).

Because the content is displayed via the local browser, developers can test their content by running it live in a browser or by downloading it direct to a mobile device.

Open Sharing: Formats for Packaging and Tracking

ZIP + XML to package mLearning files – For packaging a collection of media and HTML files, it was appropriate to leverage the more established standards for sharing eLearning content (SCORM Content Packaging), which in most cases is done by zipping up a collection of HTML pages and including core metadata to define the content. Some aspects of this approach are perfect for mobile: for example, a single file representing a package of content, in an open, Web-accessible format. Other aspects are not: for example, bloated file formats, excessive metadata, reliance on a SCORM player to support all API calls.

For content packaging, the project used a reduced version of SCORM CP, with a much lighter set of metadata. This allows the content to be entirely stand-alone, in that it can be unzipped to play directly in any mobile browser. But it can also be downloaded and unpackaged by our app, in which case it integrates seamlessly into the learning app, allowing for tracking and monitoring of progress.

Specific data about the XML format is available on the OMLET documentation site (<http://omlet.m-learning.net/docs>).

Formats for Messaging and Tracking

Traditional eLearning uses the SCORM API as a structured method to pass tracking data from the content to the learning platform. Although widely supported on the big screen, SCORM is not yet widely established in more dynamic learning environments (virtual reality, social media, etc.), or on the smaller screens required for mLearning, and is widely considered too restrictive for tracking the wide range of learning activities typical on a phone (Degani, Martin, Stead, & Wade, 2010). Several parallel initiatives are underway, sponsored by the eLearning industry, to explore alternative methods of sending progress data to a learning platform. Key ones are:

- LETSI (<http://letsi.org>): protocols for passing progress data back to a learning platform without requiring the content to be hosted by it
- Tin Can (<http://scorm.com/tincan>): a proposed replacement for the SCORM API, allowing a wider range of content hosted in multiple places to send

more descriptive update on progress. Like LETSI content does not need to be hosted on the tracking site.

Both of these standards are of interest for mLearning. The project team borrowed from each, but did not fully implement either, as these were not core requirements for the project. RESTful Web Services (<http://bit.ly/RESTful>) were used to exchange information with the Web server (similar to LETSI) and a linear stream of progress updates via a JavaScript API to pass data from the content to the app (like Tin Can).

Combining These Approaches for an Optimum Mobile Learning Format

The combination of technologies and approaches listed above proved to be a fit-for-purpose and effective solution for developing and sharing mLearning content for the target groups (work-based learners using their own smartphones). By leveraging and extending existing standards, open source projects, and appropriate concepts from eLearning, the project team were able to create a new, robust framework for mLearning development, optimised for touch-sensitive smartphones (primarily Android and iOS, but also Windows Phone).

All of the core software developed has been made available as an open-source framework (called OMLET) to encourage future projects to build on the lessons learned and extend them. This includes the back end (online catalogue), the apps themselves (iOS and Android), and sample content implementations. More details are available at <http://omlet.m-learning.net/docs>.

Conclusion

As mLearning is adopted more widely and the quality improves, it is increasingly important to ensure that good mobile content is transferrable and can work on many devices, across many networks, and in multiple languages. The MoLE project has been working towards the establishment of an open set of standards for mLearning content to allow maximum portability and re-use, without locking out the key features of the most useful tool of all: the phones themselves!

Drawing on existing standards in related domains (mobile Web, HTML, eLearning, video, zip), it has been possible to define formats for both mLearning content, and applications themselves that support open sharing and the future extensibility of mLearning across multiple devices and platforms. By embracing multiple media formats and a wide range of use case scenarios, the best possible learning content can be made available via whichever channel is available to that learner.

The formats and standards proposed do not restrict. They are built from existing, open standards and are being shared to encourage wider consensus and adoption. It is in the same spirit of openness and sharing that the project team has made available the core software frameworks used in the project (and in other commercial deployments), to demonstrate how this approach to mLearning content packages can be successfully adopted.

Currently, over 300 learners across 24 nations are using content developed to these standards (via four different initiatives), and key stakeholders in the U.S. government eLearning community have adopted this approach (and the apps) as core to all their future mobile courses.

To encourage wider adoption in the mLearning community, all the technical details, as well as the software itself, has been released as an Open Source project (OMLET) and extensively documented. The platform and content standards are continuously evolving. Ongoing dialogue and suggestions for improvements to these techniques are always welcome, and contributions to future software development are welcomed via the OMLET website.

Acknowledgments

The author now works at Qualcomm, but would like to acknowledge technical input by previous colleagues at TribalLabs, including Gustavo Hartmann, Mahdi Barakat, Jon Brasted, Octavio Nunes, Gustavo Pilcher, Chris Whitehead, Ben Smith and others.

This research was made possible by research grants awarded to TribalLabs by the Office of Naval Research Global (ONRG) and funded by the Telemedicine and Technology Research Centre (TATRC) at the U.S. Army Medical Research & Materiel Command (USAMRMC), Fort Detrick, as a contribution to the Coalition Warfare programme (CWP) (grant number: N62909-11-1-7026). The views expressed here are solely those of the author and do not represent or reflect the views of any government agency or organisation that participated in the project.

References

- ASTD (2012). *Mobile learning: Delivering learning in a connected world*. ASTD research report. Retrieved November 2012 from www.astd.org/Publications/Research-Reports/2012/2012Global
- Attwell, G., & Baumgartl, B. (Eds.) (2009). *Creating learning spaces: Training and professional development for trainers*. Vol. 9. Vienna: Navreme Publications.
- Blake, C., Adams, A., & Scanlon, E. (2011). Effectiveness of mobile learning across various settings. In CAL Conference 2011, *Learning Futures: Education, Technology & Sustainability*, 13–15 April 2011, Manchester.
- Bradley, C., Haynes, R., Cook, J., Boyle, T., & Smith, C. (2009). Design and development of multimedia learning objects for mobile phones. In M. Ally (Ed.), *Mobile learning: Transforming the delivery of education and training* (pp. 157–182). Edmonton, AB: Athabasca University Press. Retrieved June 11, 2012, from www.aupress.ca/index.php/books/120155
- Cook, J. Holley, D., Smith, C., & Bradley, C. (2006). *A blended m-Learning design for supporting teamwork in formal and informal settings*. Paper for IADIS International Conference on m-Learning, 2006.
- DeGani, A., Martin, G. Stead, G., & Wade, F. (2010). E-learning standards for an m-Learning World. Archived paper at www.m-learning.org/knowledge-centre/research
- Good Technology. (2012). State of BYOD report. Retrieved January 2013 from www1.good.com/resources/whitepapers
- Hartmann, G., & Stead, G. (2011). Cross platform mobile app development. Retrieved November 2012 from www.triballabs.net/2011/07/cross-platform-mobile-app-development/

- Hazael-Massieux, D. (2012). Standards for Web applications on mobile. Synopsis of W3C standards. Retrieved from www.w3.org/2012/05/mobile-web-app-state
- Koole, M. L. (2009). A model for framing mobile learning. In M. Ally (Ed.), *Mobile learning: Transforming the delivery of education and training* (p. 38). Edmonton, AB: Athabasca University Press.
- Kukulska-Hulme, A. (2010). Mobile learning as a catalyst for change. *Open Learning* 25(3), November 2010, 181–185.
- Pachler, N., Pimmer, C., & Seipold, J. (Eds.). (2011). *Work-based mobile learning: concepts and cases*. Oxford: Peter Lang.
- Savill-Smith, C., Attewell, J., & Stead, G. (2006). *Mobile learning in practice: Piloting a mobile learning teachers' toolkit in further education colleges*. London: Learning and Skills Network.
- Sharples, M., Taylor, J., & Vavoula, G. (2005). Towards a theory of mobile learning. In H. van der Merwe & T. Brown (Eds.), *Mobile technology: The future of learning in your hands*, mLearn 2005, 4th World Conference on mLearning, 25–28 October 2005. Cape Town: mLearn.
- Smith, C., Bradley, C., Cook, J., & Pratt-Adams, S. (2011). Designing for active learning: Putting learning into context with mobile devices. In A. D. Olofsson & J. O. Lindberg (Eds.), *Informed design of educational technologies in higher education: Enhanced learning and teaching* (pp. 307–329). Hershey, PA: IGI Global.
- Stead, G. (2012a). Mobile learning: Mind the gap. Retrieved November 2012 from <http://bit.ly/mobimoocstead>
- Stead, G. (2012b). Open standards for m-learning? Retrieved November 2012 from <http://bit.ly/openmob>
- Towards Maturity (2013). Mobile learning at work. Retrieved January 2013 from www.towardsmaturity.org/article/2013/01/15/towards-maturity-focus-report-mobile-learning-work/
- Traxler, J. (2011). The “learner experience” of mobiles, mobility and connectedness. Retrieved November 2012 from [http://mobimooc.wikispaces.com/MobiMOOC+2011+\(archived\)](http://mobimooc.wikispaces.com/MobiMOOC+2011+(archived))

Using BYOD, Mobile Social Media, Apps, and Sensors for Meaningful Mobile Learning

Inge Ignatia de Waard

Abstract

Integrating mobile learning (mLearning) into existing learning and training environments was daunting some years ago. But thanks to recent mobile developments, embedding qualitative, meaningful mLearning has become easier. Today, researchers, teachers, professors and trainers are all benefiting from employing Bring Your Own Device (BYOD) options and strategies, using sensors that are available at an increasing rate in smartphones and tablets, screening the mobile applications (apps) potential for learning, and even simply screening mobile social media for their meaningful learning implementation.

This chapter outlines the contemporary challenges that are still affecting mLearning, and stresses the need to embed mLearning in the overall learning environment. The author looks into the learning opportunities that BYOD, mobile social media, mobile apps and mobile sensors offer. Each of these elements is linked to research or corporate knowledge. These simple mLearning options are also screened for their learning additions, with practical, real life examples. Each of these mobile options offers new educational options to improve and broaden contextualised, meaningful learning. Optimising and embedding these simple mLearning tools for qualitative learning is essential to meet contemporary training and learning demands.

Introduction

“A little knowledge that acts is worth infinitely more than much knowledge that is idle.”

Khalil Gibran

We live in an Age of Mobilism, in which users want to be connected all of the time, everywhere, on devices that are affordable and globally adopted (Norris & Soloway, 2011).

Mobile learning (mLearning) is in perpetual beta. This results in an amazing turnover of all knowledge. Gonzalez (2004) referred to this phenomenon as the “half-life” of knowledge — the time span from when knowledge is gained until it becomes obsolete. As such, this chapter focuses on easy, simple mobile tools that can be used for mLearning, hoping that most of these tools will stand the test of time and allow us all to find their full learning potential. All sections are linked to the theoretical underpinnings of the concepts, but aimed at practical implementation for different contexts.

The focus on easy tools in this chapter hopes to complement the focus of the other contributing authors who have chapters in this book. Researchers, teachers, professors and trainers can all benefit from employing Bring Your Own Device (BYOD) options and strategies, using sensors that are available at an increasing rate in smartphones and tablets, screening the mobile applications (apps) potential for learning, and even simply screening mobile social media for their meaningful learning implementation is beneficial to all.

Delivering learning for mobile devices is no different from delivering any kind of learning. Therefore the effectiveness of learning/teaching depends on the vision, creativity and pedagogical understanding of those developing, delivering and supporting the learning process. This chapter links new learning affordances offered by contemporary mLearning options to mobile, contemporary learning implementation. This chapter is divided into four sections: BYOD, mobile social media, mobile applications (apps) and embedded mobile sensors.

Background

Definition of Mobile Learning

In this chapter, mLearning is defined as learning across multiple contexts, through social and content interactions, using personal electronic devices, following Crompton (2012).

Embedding mLearning in Our Overall Strategies

Embedding all the latest mLearning options into the overall training or academic curriculum in a meaningful, complementary way is a great, efficient goal to pursue. “The ubiquitous access to technology [has] forced schools, education departments and a myriad of other stakeholder in the education domain to enter into conversations about utilizing mobile technology in particular towards learning gains” (Botha, Batchelor, Traxler, de Waard, & Herselman, 2012, p.1). This emphasis on quality and efficiency is true for all educational technologies, but specifically for the contemporary drive to use mLearning. And although starting with mLearning is best done by developing a small mLearning project which adds to a learning challenge or educational niche, in the end, overall mLearning integration in a ubiquitous learning environment is the only way to provide a seamless learning environment for a fluent, motivational user learning experience. That overall goal should be the basis of all of our choices to ensure a durable mLearning solution.

Contemporary mLearning Challenges

This era provides the first time in history that learning content can be accessed via mobile devices and social media. According to de Waard et al. (2011, p. 108), “This expands knowledge acquisition beyond the traditional classrooms and libraries, hence redefining those spaces and adding to knowledge spaces overall.”

However, this ubiquity brings along many challenges. The four major ones are:

1. Technological challenges: For example, mobile standards are only growing gradually; infrastructure (including mobile bandwidth) is still being rolled out across the globe; and the diversity of phones and tablets creates difficulties for single-source content output and interactivity.
2. Geographical challenges: For example, mobile infrastructure is still unstable in certain regions; mountainous areas can make connecting difficult; and rural areas provide a high-cost investment for an insecure cost return.
3. Digital divide challenges: As mLearning is rolled out, more inequities emerge. Vulnerable groups do not always get the same access as dominant groups; gender is still a hot topic in the digital learning divide; and although taboo topics can be discussed via mLearning, their personal and private nature still means the actual taboos persist.
4. Target audience challenges: Online learning is traditionally oriented to the target audience for that particular learning. In the past, knowing your target audience was enough to get the instructional designer on his or her way. However, with mLearning, that is no longer the case. Target audiences are more complex: mobile, digital literacy can vary; devices will vary; and users will have different mobile experiences.

Given these challenges, working with what is out there already and the tools to which the learners have access is a strategic choice.

BYOD

As more training moves into “the cloud” (cloud computing), enabling mobile access is all the rage. Setting up learning spaces within reach of a diversity of learners and their mobile devices enables everyone to connect to the world with their regional devices of preference (smartphones, netbooks, tablets, computers, e-readers, etc.). Educators should focus on integrations into the curriculum that include mobile devices and a focus on meaningful incorporation of “bring your own device” (BYOD) (Smart and Gournau, 2012).

BYOD is being deployed increasingly in the corporate world. Martin Duursma from Citrix said in 2011 that within 5–10 years, BYOD will be run by 70–80% of organisations (Brewster, 2011). But the learner impact of BYOD in education is similarly attractive. Preliminary results indicate that opening up courses for BYOD mobile access will increase learner interactions (both social and professional) by 25% (de Waard, 2013). This increase in learner interaction does not only affect the actual discussions and sharing of knowledge between course participants, it also increases the community feeling of the participants taking part in the course.

An additional benefit of choosing to opt for BYOD is the cost. According to Harris (2012), who wrote Trend Micro’s IT Executive and CEO Survey, most of

the organisations polled reported that costs either decreased or remained the same after introducing BYOD. The reasons included: the lowering of IT capital expenditure (due to users purchasing their own devices); reduced desktop computing support costs; and increased employee productivity (Harris, 2012).

Basic Steps to Start BYOD

There are five basic tips to optimising BYOD options for your mLearning projects.

1. Use mobile-enabled social media tools (the next section of this chapter focuses on this topic).
2. Keep graphics relatively small and uncomplicated. Do not use huge graphics that demand close-ups to make the numbers and details on them readable.
3. Use simple Web standards as much as possible. Everyone talks about HTML5 and CSS3 (www.w3schools.com), but if you are simply using pictures and text, designing with basic HTML and CSS will get you there as well. An added bonus is that HTML5 and CSS3 allow multimedia to be embedded.
4. Use tools built into the mobile devices (e.g., mobile sensors; discussed later in this chapter).
5. Test your content and your course interactions on a wide variety of devices.

Basic Steps for BYOD Delivery or Capture

There are also five basic tips for optimising the use of the BYOD delivery or capture.

1. Be sure to promote and explain Wi-Fi use. This will reduce download costs for your learners and participants.
2. Use small-sized chunks, or “learning snacks” (otherwise it takes forever to download). For example, adjust your movie quality or cut multimedia into downloadable and reviewable parts.
3. Assure user friendliness. Give links straight to content (one-button access) and use QR-codes and RSS feed links. The QR-codes provide easy mobile access (if your users have a QR-code reader). The RSS feeds allow learners to get any newly published content pushed to their preferred digital location.
4. Build for lowest common denominator. Do not use Flash (or limit its use). Do use text and pictures for quick access. Only use more complex multimedia files when relevant for the content. Or use email for main content updates (easy and cross-platform).
5. Test your content both with a pilot group and with a larger group, covering as many devices as possible. Better yet, use crowd sourcing to get feedback on the different mLearning media and locations you will be using. Be sure to do this before formally launching your course — it is well worth the time investment.

Other Factors to Consider for BYOD

Also consider, when rolling out a BYOD option:

- setting up a BYOD strategy for your institute or organisation;
- providing a BYOD policy, making sure people know what they can or cannot do; and
- assuring BYOD security (this is related to the IT challenges associated with providing content via a diversity of mobile devices).

As Emery (2012, p. 90) put it, “an IT strategic plan should support the institutional mission and align with the institutional strategic plan. An IT strategy for BYOD is not only forward-thinking, it can also bring about a cost savings for an institution.” And in Thomson’s view (2012), “the BYOD issue is less a matter of ‘No, we can’t do it’ and more a question of ‘How do we do it?’”

One of the options to move toward a BYOD mLearning project is to embed mobile social media.

Mobile Social Media

With social media becoming a part of everyday connected life, it is important to analyse these media for their learning/teaching possibilities. An overview is provided here of which type of mobile social media tools can be used for which learning or teaching goal.

Social media tools have a profound effect on pedagogy (Carsten et al., 2008). The most profound pedagogical changes introduced to the learning/teaching process are the social dimension captured by the harnessing of collective intelligence, and the fact that Web 2.0 enables and facilitates the active participation of each user (Carsten et al., 2008; Shriram & Warner, 2010). The mere fact of using social media implies that at least a consumption of information is taking place. At best, the production and digestion of content delivered via social media result in knowledge creation by the learner.

Cochrane (2010, p. 2) outlines a pedagogical framework for mobile teaching and its alignment with Web 2.0 social software in his reflective action research. He states: “M-learning (mobile learning) technologies provide the ability to engage in learning conversations between students and lecturers, between student peers, students and subject experts, and students and authentic environments within any context.” This covers most of contemporary learner interactions.

McElvaney and Berge (2010, p. 8) link social media tools to their educational potential: “The majority of personal web technologies have mobile-friendly versions available, allowing individuals to take their learning to go Mobile versions of personal web technologies give learners more option on where and when to learn.”

Table 9.1 shows a sample of mobile social media tools, listed with their learning and teaching potential and a couple of example applications. This list is a work in progress that builds on choosing from the mobile-enabled social media toolkit as mentioned by de Waard (2012).

Table 9.1: Mobile social media tools

Social media tool	Why use it + implementation	Example with possible extras
Idea and content sharing through microblogging	<p>Twitter allows the global learner group to share short messages with one another, linking it to more content.</p> <p>Twitter is an ideal tool for short Q&A interaction and for organising chats around specific topics while using hashtags.</p> <p>Real life: Educators have Twitter meetings where they discuss a particular educational issue (#lrnchat).</p>	<p>Twitter</p> <p>Extra: A hashtag (#) can be used to keep on track with specific topics. (For all tweets regarding mLearning, see https://twitter.com/search?q=%23mlearning.)</p> <p>Twitterchats can be organised by people or organisations and focus on specific topics. Example of Twitterchat: #lrnchat (http://lrnchat.wordpress.com/)</p>
Social networking	<p>Building a network of people can add to the knowledge creation of the learner.</p> <p>Real life: People with mutual interest in management can join up in a group to discuss strategies (LinkedIn)</p> <p>Social networking is increasingly adding to the Personal Learning Network that learners are creating to stay on top of current knowledge evolutions in their area of interest.</p>	<p>Facebook</p> <p>Google+</p> <p>Yammer (private, secure social networking)</p> <p>LinkedIn</p> <p>Extra: LinkedIn has a feature enabling a user to send Q&As to their professional network. This is a meaningful way to stay in touch.</p>
Social bookmarking	<p>Social bookmarking allows the learner group to find bookmarked items related to the topic at hand gathered in one place.</p> <p>Real life: This enables organising online resources relevant to one's learner group (e.g., augmented learning, class resources).</p>	<p>Diigo (which also has networking and sharing options)</p> <p>Delicious</p>
Multimedia sharing	<p>Sharing visuals, audio and/or movies gives others an in-depth view on what is happening.</p> <p>Real life: Multimedia sharing enables the sharing of authentic learning. For example, healthcare workers can share X-ray pictures and diagnoses (Telemedicine).</p>	<p>Video (e.g., YouTube, Vimeo).</p> <p>Audio (e.g., Skype)</p> <p>Pictures (e.g., Flickr, Picasa)</p> <p>Extra: A good copyright should be chose, such as Creative Commons licences.</p> <p>Extra: Geotagging involves sharing the location of the object of the video, audio or picture. This metadata can later be used for additional learning tracks or research.</p>
Shared workspaces	<p>These allow synchronous or asynchronous collaboration on content, strategies and planning, storage of knowledge, and overview updating.</p> <p>Real life: These enable getting a team on the same page by allowing everyone to give feedback to a proposal, or to start a proposal through common interests.</p> <p>They also make it easy to keep on top of the latest knowledge by adding each new feature or piece of information to the central document and deleting the outdated data (e.g., medical checklists).</p>	<p>Asana can be used for keeping a project with different members and tasks organised (available for iPhone).</p> <p>Google docs is a mobile version.</p> <p>TitanPad is a real-time collaborative tool.</p> <p>Wikis (Wikispaces has a special educational option)</p> <p>Extra: Wikis are difficult to edit via mobiles. PicoWiki is, however, a wiki designed for mobiles and is easy to edit.</p>
Blogs	<p>Blogs can be used by learners to reflect on what they learned and what they think is of importance; and to keep a learning archive or personal learning environment.</p> <p>Real life: Engineers can keep track of complex issues they encounter in the field and explain how they solved them. These accounts can later be used in similar situations.</p>	<p>WordPress</p> <p>Blogger</p> <p>Posterous</p> <p>Special mention must be made of Posterous. This blogging tool enables any group member to email content to a variety of social media tools, including Flickr, Facebook and Twitter.</p>

Social media tool	Why use it + implementation	Example with possible extras
Virtual meetings	<p>Virtual meeting tools allow synchronous communication to take place. These are great for collaborative discussions/brainstorming.</p> <p>Real life: Sales protocols are provided asynchronously and learners need to go through them. Afterwards, virtual meetings are set up to role-play what is learned and to discuss the protocols.</p>	<p>Google hangout (nice embedding in YouTube)</p> <p>Skype</p> <p>Big Blue Button (open-source project)</p> <p>Wiziq (free and with mobile options)</p> <p>Blackboard Collaborate</p> <p>Webex</p>
Collaborative reference managers	<p>These are for those learners interested in research or formal accreditation.</p> <p>Real life: These make it easy for users to access citations, build reference lists, create literature reviews and add notes.</p>	<p>Mendeley</p> <p>Zotero</p>
Collaborative mindmapping	<p>This enables planning or structuring thoughts, future steps and content.</p> <p>Real life: Teachers can come together to set up a new curriculum, collaboratively building the course architecture.</p>	<p>Mindmeister</p> <p>Mindjet</p>
Augmented reality additions	<p>These are great for adding authentic information to geo-located spaces, and for showing relevant and contextualised 3D objects that are triggered via QR-codes.</p> <p>Real life: Users can see archeological history unfold over centuries, simply by looking at their mobile device. Augmented content can exist of simulations, videos, text, real-life enactments, or any other creative option that teachers or their mobile learners can come up with.</p>	<p>Wikitude</p> <p>Layar</p> <p>Junaio</p>
Sharing presentations	<p>Sharing presentations offers an immediate way of enhancing knowledge on a subject.</p> <p>Real life: This can be used for assignments. Learners can be asked to build a presentation and share it, and can discuss each other's work.</p>	<p>Slideshare lets users search for the slides the wish to view (www.slideshare.net/mobile/nameUser/namePresentation)</p>

Using mobile-enabled social media opens up a wide variety of learning/teaching options that are based on simple, manageable guidelines taken up by all stakeholders involved in education or training. But it becomes much more complex to provide guidelines when there is an abundance of tools to choose from, which is the case with the wide variety of mobile applications.

Mobile Applications (Apps)

The Pew Research Center’s Internet and American Life Project defines mobile applications (or apps) as “end-user software applications that are designed for a cellphone operating system and which extend the phone’s capabilities by enabling users to perform particular tasks” (Purcell, Entner, & Henderson, 2010, p. 2). Mobile apps offer a massive amount of learner options. However, there are so many mobile native applications out there that there is no way anyone would be able to go through them all. Luckily, most apps are reviewed by the users, which makes screening apps for specific topics a bit easier based on that feedback. Mobile applications can have a variety of educational formats: serious games, flashcard type of information deliverers, etc. It is of interest to screen what types of apps are out there for a specific field — for example, algebra, language learning and so on — and to screen those that get high ratings by their users. But it is not only about the

app, as Ellis (2012, p. 124) notes: “mobile applications have the benefit of relatively easy deployment and broad accessibility to a range of users.”

“Mobile applications are often easy for students to relate to, because mobile technology plays an increasingly important role in the lives of today’s students (Kurkovsky, 2012, p. 124). This is substantiated by a remarkable mobile app development: In June 2012, an mLearning app called DragonBox, which teaches anyone interested in the finer basics of algebra, managed to get downloaded more times than the much-applauded Angry Birds. This pushed mobile applications further along the map of educational possibilities, as for the first time a serious game beat other gaming options available.

According to the World Bank’s report “Information and Communications for Development 2012: Maximizing Mobile,” more than 30 billion mobile applications were downloaded in 2011 — software that extends the capabilities of phones to become, for instance, mobile wallets, navigational aids or price comparison tools.

University App Development

Several universities are already rolling out their own mobile applications to enable their students to stay in contact with their course material. The first university to roll out a campus-wide mobile application was the Open University of the United Kingdom. With their mobile app called OUAnywhere, they offer all the undergraduate materials for mobile access. This is an interesting development, as it takes formally recognised qualification right onto personal mobile devices.

Mobile Apps Versus Mobile Web

Once smartphones started to take off, mobile native apps were the only way to retrieve information in an instant, for mobile browsing was still slow. But now, with the ever-growing speed of mobile browsers and the increase of powerful mobile bandwidths all around the world, mobile Web applications often offer the same user-friendly access as their native counterparts.

In the discussion about mobile apps and mobile Web, Tony Smith of the Open Source Developers Club in Melbourne, Australia, made this distinction in their use: “Both will continue to grow in ways that are impossible for most to imagine... Apps are generally better for narrowly defined repetitive tasks, especially where your needs can be narrowed by your location, time, etc. The Web will remain better for asynchronous exploring and continue its gateway role” (Anderson & Rainee, 2012, p. 7).

An interesting part of these mobile apps is the use of existing smartphone and tablet sensors for learning purposes.

Mobile Sensors

An interesting development in the smartphone area is the rise in phone sensors that are embedded in those devices. Says De Jong (2011, p. 122), “Mobile device sensors, like for example GPS and barcode sensors, provide easy ways to adapt learning media to a location and objects in the learner’s vicinity.” There are

already eight fairly common mobile sensors, but the number is expanding rapidly. Sensors open up new opportunities for applied learning. Mobile apps often make use of these sensors for the overall app experience, but the sensors can also be used for their own, stand-alone function.

Growing Sensor Development

In planning innovative learning, it is interesting to look at the learning options provided by mobile sensors. “Nowadays, mobile devices can be context-aware of their environment, and already have built-in sensors ranging from location sensors to detailed 3D movement gyroscopes” (Specht et al., 2012, p. 26).

Sensors will become increasingly pervasive as their applications increase and production costs decrease. As De Jong (2011, p.53) puts it, “The use of web-based content furthermore makes it possible to use *lightweight, easily portable clients* that integrate a web-browser to display the learning content, and provide device-specific software to provide access to sensors.” This move towards mobile sensors affects many disciplines. One field of interest is mobile health (mHealth) related learning. Simple implementations are already used on a daily basis, such as for measuring heart rate, blood pressure and so on. However, with the rise of blood and urine analysis options (e.g., simple sensors that only need a small drop of blood, toilets equipped with protein analysers, the ability to send data to mobiles for analysis), the future will allow us to learn from these results and adapt our health to it. This diverse corporate interest in mobile sensors will push the development for sensors catering to a variety of contextualised learning needs forward.

The number of sensors available in both smartphones and tablets is increasing rapidly. Some of these sensors are focusing more on increasing the overall mobile device user experience (e.g., luxmeter). Other sensors open possibilities related to mobile devices. Table 9.2 lists four widely available mobile sensors being screened for their possible learning options.

Table 9.2: Mobile sensors for learning integration

Sensor name	Short description	Learning options
Microphone	Most commonly known sensor to detect audio	Useful for: <ul style="list-style-type: none">• recording audio in a specific location (e.g., sound of specific birds) or from specific people (interviews)• creating podcasts/MP3 focusing on specific topics
GPS	Global Positioning System	Useful for field trip activities (e.g., treasure hunts, locating specific vegetation, finding monuments). Maximum precision is a few metres, so a good additional description of the object or space learners are to engage with is still needed. When linked to Google maps, it opens up indoor options.
Accelerometer	A sensor that detects the orientation, motion and rotation of the device based on three axes	Useful for many space applications (e.g., detecting stars and planets in the midnight sky). It is also used for sporting purposes, such as measuring altitude and speed. The screen can be optimised for optimal viewing.
Barcode reader	A sensor that identifies a barcode and the information stored on it	Useful for augmenting reality scenarios, as the sensor provides immediate and contextualised access to additional content through the barcode. This content can be in the form of text, pictures or multimedia. It can also link to other online resources and ask people to add their content to a specific location.

Conclusion

The rise of mobile devices opens up a whole array of new learning opportunities, beyond the walls of the traditional classroom or training centres. Optimising and embedding these simple mLearning tools for qualitative learning is essential to meet contemporary training and learning demands.

To add mLearning to an overall learning/teaching strategy, four easy-to-implement options can be screened and embedded in the learning environment: BYOD, mobile social media, mobile apps and mobile sensors. Each of these mobile options offers new educational opportunities that can be used to improve and broaden contextualised, meaningful learning.

References

Anderson, J., & Rainee, L. (2012). *The future of apps and web*. Washington, DC: Pew Research Center’s Internet and American Life Project. Retrieved November 2, 2012, from www.pewinternet.org/Reports/2012/Future-of-Apps-and-Web.aspx

Botha, A., Batchelor, J., Traxler, J., de Waard, I., & Herselman, M. (2012). Towards a mobile learning curriculum framework. In P. Cunningham & M. Cunningham (Eds.), *Proceedings of IIMC International Information Management Corporation*. IST-Africa 2012.

Brewster, T. (2011). Thin clients aren’t the future, BYOD should be. [corporate newsletter]. Retrieved November 10, 2012, from www.itpro.co.uk/637018/thin-clients-aren-t-the-future-byod-should-be

- Carsten, U., Kerstin, B., Heng, L., Xiaohong, T., Liping, S., & Ruimin, S. (2008). Why Web 2.0 is good for learning and for research: Principles and prototypes. *Proceedings of the 17th International World Wide Web Conference*.
- Chiong, C., & Shuler, C. (2010). Learning: Is there an app for that? Investigations of young children's usage and learning with mobile devices and apps. New York: The Joan Ganz Cooney Center at Sesame Workshop.
- Cochrane, T. (2010). Smartphones give you wings: Pedagogical affordance of mobile Web 2.0. *Australasian Journal of Educational Technology* 26(1), 1–14.
- Crompton, H. (2012). mLearning definitions. In Z. L. Berg & L. Y. Muilenburg (Eds.), *Handbook of mobile learning*. New York, NY: Routledge.
- De Jong, T. (2011). *Contextualized mobile media for learning*. Doctoral dissertation, Open University of the Netherlands, Heerlen, the Netherlands. Retrieved October 22, 2012, from <http://hdl.handle.net/1820/3403>
- de Waard, I. (2012). mMOOC design: Ubiquitous, open learning in the cloud. In Z. L. Berg & L. Y. Muilenburg (Eds.), *Handbook of mobile learning*. New York, NY: Routledge.
- de Waard, I. (2013). *The impact of mobile access on learner interactions in an open, online course*. Master's thesis, Athabasca University, Alberta, Canada.
- de Waard, I., Abajian, S., Gallagher, M., Hogue, R., Özdamar Keskin, N., Koutropoulos, A., & Rodriguez, O. (2011). Using m-learning and MOOCs to understand chaos, emergence, and complexity in education. *The International Review of Research in Open and Distance Learning*, 12(7), 94–115.
- diFilipo, S., & Kondrach, C. (2012). Rolling out a BYOD (Bring Your Own Device) program. EDUCAUSE webinar. Retrieved October 28, 2012, from www.educause.edu/library/resources/rolling-out-byod-bring-your-own-device-program
- Emery, S. (2012) Factors for considering when developing a Bring Your Own Device (BYOD) strategy for Higher Education. Research paper for Master's degree in Applied Information Management, University of Oregon. Retrieved November 5, 2012, from <http://hdl.handle.net/1794/12254>
- Gonzalez, C. (2004). The role of blended learning in the world of technology. Retrieved November 3, 2012, from www.unt.edu/benchmarks/archives/2004/september04/eis.htm
- Harris, C. (2012). IT executive and CEO survey final report: Mobile consumerization trends and perceptions. Trend Micro (2012). *Enterprise readiness of consumer mobile platforms*. Retrieved October 26, 2012, from http://trendmicro.com/cloudcontent/us/pdfs/business/reports/rpt_enterprise_readiness_consumerization_mobile_platforms.pdf?cm_mmc=Affiliates_-_Internal_-_Cesare+Garlati_-_BringYourOwnIT
- Jackson, S., Ellis, H., Postner, L., Kurkovsky, S., & Mustafaraj, E. (2012). Mobile application development in computing curricula. *Journal of Computing Sciences in Colleges*, 27(6), 123–125.

- McElvaney, J., & Berge, Z. (2010). Weaving a personal Web: Using online technologies to create customized, connected, and dynamic learning environments. *Canadian Journal of Learning and Technology/La revue canadienne de l'apprentissage et de la technologie*, 35(2).
- Norris, C. A., & Soloway, E. (2011). Learning and schooling in the age of mobilism. *Educational Technologies*, 51(6), 3–10. Retrieved November 6, 2012, from <http://cecs5580.pbworks.com/w/file/fetch/50304204/Soloway%20Ed%20Tech-Learning%20and%20Schooling%20in%20the%20Age%20of%20Mobilism.pdf>
- Purcell, K., Entner, R., & Henderson, N. (2010). The rise of apps culture. Washington, DC: Pew Research Center's Internet and American Life Project. Retrieved November 2, 2012, from <http://pewinternet.org/Reports/2010/The-Rise-of-Apps-Culture.aspx>
- Raths, D. (2012). Are you ready for BYOD? *The Journal*, 39(4), 28–32. Retrieved November 26, 2012, from http://thejournal.com/Articles/2012/05/10/Are-You-Ready-for-BYOD.aspx?sc_lang=en&p=1
- Shriram, R., & Warner, S. C. (2010). Connectivism and the impact of Web 2.0 technologies on education. *Asian Journal for Distance Education*, 8(2), 4–17.
- Smart, K., & Gourneau, B. (2012). Digital disconnects in teacher education: Exploring the integration of personal technology into classroom instruction. *Proceedings of the National Social Science Conference*, Vol. 49 (2).
- Smith, J., & Straight, R. (2011). The development and delivery of custom mobile apps for K–12 learning: Viable options for educators. In M. Koehler & P. Mishra (Eds.), *Proceedings of Society for Information Technology & Teacher Education International Conference 2011* (pp. 3102–3107). Chesapeake, VA: AACE.
- Specht, M., Börner, D., Tabuenca, B., Ternier, S., De Vries, F., Kalz, M., Drachsler, H., & Schmitz, B. (2012). RTST trend report: Lead theme: Contextualisation. Deliverable 1.7 of STELLAR network of excellence. Heerlen, The Netherlands. Retrieved November 5, 2012, from <http://dspace.ou.nl/handle/1820/4356>
- Thomson, G. (2012). BYOD: Enabling the chaos. *Network Security*, 2, 5–8. doi:10.1016/S1353-4858(12)70013-2
- Vogel, D., Kennedy, D., & Chi-Wai Kwok, R. (2009). Does using mobile device applications lead to learning? *Journal of Interactive Learning Research*, 20(4), 469–485.
- World Bank. (2012). *Information and communications for development 2012: Maximizing mobile*. Washington, DC: World Bank. doi: 10.1596/978-0-8213-8991-1. Retrieved November 2, 2012, from www.worldbank.org/ict/IC4D2012

Supporting Mobile Access to Online Courses: The ASK Mobile SCORM Player and the ASK Mobile LD Player

Panagiotis Zervas and Demetrios G. Sampson

Abstract

Over the last decade, a number of international efforts have led to the development of specifications and standards in the field of technology-enhanced learning (TEL) that are related with online course design, packaging and delivery. Examples include the Sharable Content Object Reference Model (SCORM) and the IMS Learning Design (LD) Specification. These standards aim to allow online courses to be designed and packaged in a commonly agreed machine-readable format that can be used by different delivery systems, referred to as course players. On the other hand, the widespread ownership of mobile devices has led to research initiatives that investigate the potential educational benefits from enabling learners' access to online courses without place and device constraints. Nevertheless, most course players are currently developed with desktop PCs as the delivery end. Existing mobile course players mainly support SCORM but not IMS LD and most of them are commercial products. As a result, there are limited open-source implementations of mobile course players, which support delivery of online courses and conform with SCORM or IMS LD. This chapter takes stock of the current landscape of available commercial and/or open-source mobile course players and describes an open-source mobile course player suitable for delivering SCORM courses — namely, the ASK Mobile SCORM Player — as well as an open-source mobile course player suitable for delivering IMS LD courses — namely, the ASK Mobile LD Player.

Introduction

Over the last decade, there have been significant standardisation efforts in the field of technology-enhanced learning (TEL) led by a number of standardisation committees and initiatives: the Aviation Industry CBT Committee (AICC); the IMS Global Learning Consortium (IMS GLC); the Advanced Distributed Learning (ADL)

Initiative; the IEEE Learning Technology Standards Committee (LTSC); the European Committee for Standardisation CEN/ISSS Workshop on Learning Technology (WS/LT); and the ISO/IEC JTC1/SC36 (Joint Technical Committee Information technology for learning, education and training) (Bush, Walker, & Sorensen, 2011).

The main outcome of these standardisation efforts was the development of a number of TEL standards that fall into two basic categories (Devedzic, Jovanovic, & Gesevic, 2007; Sanchez-Alonso, Lopez, & Frosan-Wilke, 2011):

1. learners' interoperability standards, which define how learners' data (such as learners' profile and interactions with learning content and the learning system) can be exchanged between different systems and platforms; and
2. course packaging standards, which define how educational resources, learning activities and online courses should be packaged for facilitating interoperability between different systems and platforms.

Two course packaging standards have attracted the attention of researchers and practitioners in the field of TEL: the Sharable Content Object Reference Model (SCORM) (Dodds & Thropp, 2006) and the IMS Learning Design (LD) Specification (IMS GLC, 2003). SCORM and IMS LD allow online courses to be designed and packaged in a commonly agreed machine-readable format that can be used by different delivery systems, referred to as course players (Gonzalez-Barbone & Anido-Rifon, 2008). The main difference between SCORM and IMS LD is that SCORM is based on a single learner model, whereas IMS LD, while also able to model single learner situations, allows multi-learner situations such as group and collaborative learning activities to be modelled. Additionally, SCORM supports only packaging of educational resources, whereas IMS LD considers that learning activities can be performed in a learning environment, which includes educational resources as well as specific tools and services (Qu & He, 2009).

On the other hand, the widespread ownership of mobile devices and the growth of the mobile communications industry have offered a number of benefits to the end-users of mobile devices including: a) Internet access; b) group text, voice and/or video communication via wireless and cellular networks; c) digital content-sharing in various formats (text, image, audio, video); and d) location-aware information delivery and personalised assistance according to end-users' preferences, needs and characteristics — all without place and device restrictions (Herrington, Herrington, Mantei, Olney, & Ferry, 2009; Sharples & Roschelle, 2010). Mobile devices are recognised as an emerging technology with the potential to facilitate teaching and learning strategies that exploit real-life context (Cobcroft, Towers, Smith, & Axel, 2006; Jeng, Wu, Huang, Tan, & Yang, 2010; Johnson, Levine, & Smith, 2009).

More precisely, mobile devices can:

- engage students in experiential and situated learning without place, time and device restrictions;
- enable students to continue learning activities, initiated inside the traditional classroom and outside the classroom through their constant and contextual interaction, and communication with their classmates and/or their tutors;

- support on-demand access to educational resources regardless of student location and/or device used;
- allow new skills or knowledge to be immediately applied; and
- extend the traditional teacher-led classroom scenario with informal learning activities performed outside the classroom.

Within this context, enabling online courses packaged with SCORM or IMS LD to be delivered via mobile devices is an important step for extending interoperability of course players in the mobile context, too. Nevertheless, most of course players are currently developed considering desktop PCs as the delivery end (Zatarain-Cabada et al., 2009). On the other hand, existing mobile course players mainly support SCORM but not IMS LD, and most of them are commercial products. As a result, there are limited open-source implementations of mobile course players, which support delivery of online courses that are conformant with SCORM or IMS LD. Within this framework, this chapter takes stock of the current landscape of available commercial and open-source mobile course players and presents an open-source mobile course player suitable for delivering SCORM courses, namely the ASK Mobile SCORM Player, as well as an open-source mobile course player suitable for delivering IMS LD courses, namely the ASK Mobile LD Player.

The next section provides an overview of TEL standards and their expected benefits and presents an elaborated description of two widely known content packaging standards: SCORM and IMS LD. Following that, we compare existing mobile course players that conform with SCORM or IMS LD; present the architectural components and functionalities of the proposed mobile courses players — the ASK Mobile SCORM Player and the ASK Mobile LD Player. Finally, we discuss our main conclusions and ideas for future work.

Technology-enhanced Learning Standards

Overview

The TEL community mainly uses the world standard to describe the following concepts (Devedzic et al., 2007):

- **Official standard:** Describes a set of requirements and design guidelines for TEL systems or their architectural components that a recognised standardisation organisation (such as ISO/IEC JTC1/SC36, IEEE LTSC and CEN/ISSS WS/LT) has documented and approved.
- **De facto standard:** The same as an official standard, but widely accepted only by the TEL community and industry. This means that it is lacking formal approval from a recognised standardisation organisation.
- **Specification:** The same as a de facto standard, and usually developed and promoted by individual organisations or consortia of partners from industry or academia, such as IMS GLC. It is commonly used by the members of the TEL community, but it does not capture a wide consensus of all TEL community members.

- **Reference model:** An adapted and reduced version of a combination of standards and specifications focusing on architectural aspects of a TEL system, definitions of part of parts of the system and their interactions.

The definition and adoption of complete and sound TEL standards can offer a number of benefits to all relevant actors in TEL (learners, educational content suppliers, instructional designers, TEL services providers and TEL systems designers/developers). Among such benefits, as summarised by Varlamis and Apostolakis (2006):

- **Learners** will be able to transfer their data (profile, achievements and tracking data) with minimal transition cost, between different TEL systems and platforms that follow the same TEL standards.
- **Educational content suppliers and instructional designers** will be able to develop educational resources, learning activities and online courses in a standard commonly agreed format, instead of developing the same educational resources, learning activities and online courses into many formats for delivery to different TEL systems and platforms.
- **TEL services providers** will not need to put efforts for the development of custom solutions into integrating their TEL services with the different existing TEL platforms and systems, since they will be able to follow the same TEL standards.
- **TEL systems designers/developers** will be able to select reusable systems components and create mashups of TEL systems and platforms. They will be able also to offer back to the TEL development community new mashups for future TEL systems and platforms.

An important part of standardisation efforts focuses on course packaging standards (Alves & Uhomobhi, 2010). Two course packaging standards commonly used by researchers and practitioners in the field of TEL are the Sharable Content Object Reference Model (SCORM) and the IMS Learning Design (LD) specification.

Sharable Content Object Reference Model (SCORM)

SCORM is a collection of standards and specifications developed by the ADL initiative in 1999 with the aim of integrating — in one reference model — standards for educational resources metadata, educational content packaging, and recording of learners' interactions with educational resources via course players (Dodds & Thropp, 2006). The first version of SCORM (1.2) was released in October 2001. It focused on content packaging of static navigation structures of educational resources. The current version of SCORM is version 1.3 (also known as SCORM 2004) and it provides the capability to define rules for dynamic sequencing and navigation to educational resources during run-time based on learners' actions and achievements (Lu & Chen, 2006). The current version of SCORM includes three parts (Dodds & Thropp, 2006):

- **Content aggregation model (CAM):** Describes the structure of educational resources used in an online course, how to package these educational resources for exchange between different TEL systems and platforms, and how to describe these educational resources with metadata for supporting search and discovery from Web-based repositories.

- **Run-time environment (RTE):** Describes how educational resources are launched and the learner's progress is tracked and reported back. RTE sends information back and forth to the learner, who interacts with educational resources and the course player.
- **Sequencing and Navigation (S&N):** Describes how the learner navigates from one educational resource to another, as well as the sequence in which educational resources will be presented to the learner according to his/her actions and achievements during run-time. This part of SCORM is only included in SCORM2004.

IMS Learning Design (LD) Specification

The IMS Learning Design (LD) Specification was developed by IMS GLC in 2003, with the aim of providing a standard notation language for describing learning designs (IMS GLC, 2003). Koper and Olivier (2004, p. 98) define a learning design as a “description of the teaching-learning process, which follows a specific pedagogical strategy or practice that takes place in a unit of learning (e.g., an online 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.”

The IMS LD specification follows the metaphor of a theatrical play. This means that the learning process is represented as a play including a sequence of acts, with each act containing a number of role parts that connect the roles to the learning activities the students perform and to the educational resources they use (Koper & Olivier, 2004). In IMS LD, a learning design can be built at three different levels, as follows (Koper & Burgos, 2005):

- **Level A:** Contains 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).
- **Level C:** Adds notifications that can facilitate reconfiguring design based on run-time events.

This IMS LD can support the design, packaging and delivery of dynamic learning activity flows of online courses in a multirole setting. This is also its main difference from SCORM, which is based on a single-learner model, where the learner interacts only with the educational resources and the learning environment.

Related Work: Mobile Course Players

Mobile Learning

Mobile learning (mLearning) is typically 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 (Kukulka-Hulme, 2009; Traxler, 2009). The main benefits of mLearning are that it:

- enables on-demand access to learning resources and services, as well as instant delivery of notifications and reminders (Traxler, 2009);
- offers new opportunities for learning that extend beyond the traditional teacher-led classroom-based activities (Kukulska-Hulme, 2009);
- encourages learners to participate more actively in the learning process by engaging them in authentic and situated learning (Herrington et al., 2009; Kukulska-Hulme, 2009);
- enables learning and performance support by exploiting real-life context (Kukulska-Hulme, 2009); and
- supports on-demand access, communication and exchange of knowledge with experts, peers and communities of practice (Sharples & Roschelle, 2010).

Existing Mobile Course Players Conformant with SCORM or IMS LD

The review of existing mobile course players that conform with SCORM or IMS LD reveals that: there are many commercial mobile SCORM players but only one open-source implementation; and there are no existing commercial mobile IMS LD players but there is one existing open-source implementation.

Typical examples of commercial mobile SCORM players are:

- Upside Learning (www.upsidelearning.com/)
- Litmos Mobile (www.litmos.com/mobile-learning/)
- eXact Mobile (www.exact-learning.com/en/products/learn-exact-suite/exact-mobile-solution-for-mobile-learning)
- Xyleme (www.xyleme.com/solution/mobile-learning)
- Intuition Mobile (www.intuition.com/solutions/mobile-learning/intuition-mobile/)
- Rapid Intake (rapidintake.com/mlearning-sync)

On the other hand, the only existing non-commercial implementation of a mobile SCORM Player has been proposed by Padiadpu (2008). This is an open-source mobile course player able to deliver SCORM courses via mobile devices that are running the Google Android operating system. The course player supports delivery of SCORM version 1.2 packages, as well as SCORM 2004 packages. However, sequencing and navigation rules are ignored from SCORM 2004 packages when they are imported to the player.

Finally, the only existing non-commercial implementation of a mobile IMS LD Player has been proposed by Zualkernan, Nikkhah, and Al-Sabah (2009). This is an open-source mobile course player able to deliver IMS LD courses via mobile devices that are running the Google Android operating system. However, this player supports only a sub-set of IMS LD Level A and Level B elements.

Table 10.1 presents an overview of existing mobile course players, describing the versions of SCORM that are supported by each player and conformance with different IMS LD levels. Moreover, the operating system that each player can be used on is presented. As the table shows, the commercial mobile course players fully support both versions of SCORM but they do not support IMS LD. Moreover, they have two versions: one suitable for iOS mobile devices and

another suitable for mobile devices that run the Android operating system. On the other hand, open-source implementations are mainly addressing mobile devices with an Android operating system and it seems that conformance with SCORM or IMS LD is only partially supported.

Table 10.1: Existing mobile course players

Course player	Commercial	SCORM v1.2	SCORM 2004	IMS LD			Operating system
				Level A	Level B	Level C	
Upside Learning	Yes	✓	✓	-	-	-	iOS, Android
Litmos Mobile	Yes	✓	✓	-	-	-	iOS, Android
eXact Mobile	Yes	✓	✓	-	-	-	iOS, Android
Xyleme	Yes	✓	✓	-	-	-	iOS, Android
Intuition Mobile	Yes	✓	✓	-	-	-	iOS, Android
Rapid Intake	Yes	✓	✓	-	-	-	iOS, Android
Padiadpu (2008)	No (open source)	✓	✓ (partially)	-	-	-	Android
Zualkernan et al. (2009)	No (open source)	-	-	✓ (partially)	✓ (partially)	-	Android

The ASK Mobile SCORM Player

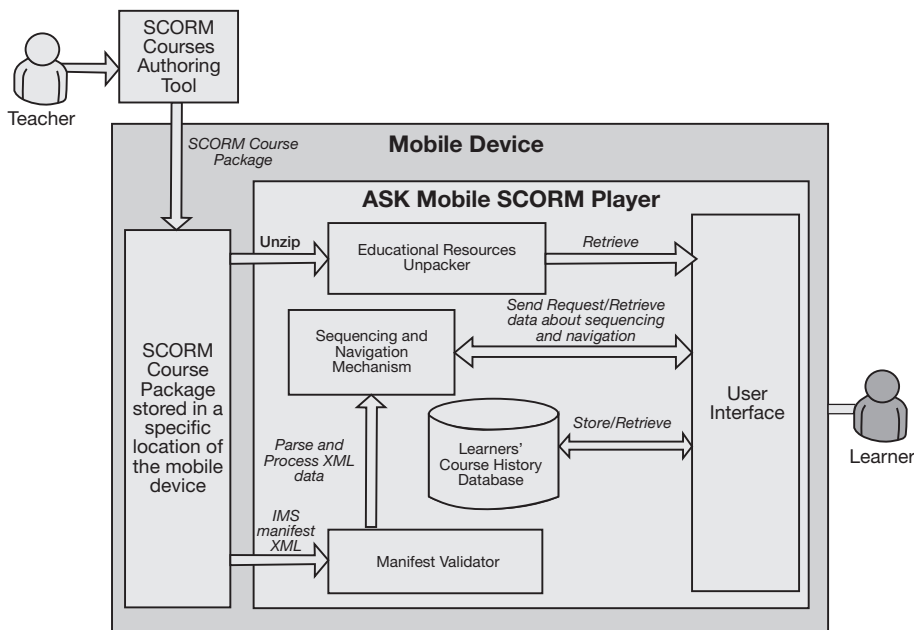
Overview and Architecture

The ASK Mobile SCORM Player is a native application suitable for mobile devices with an Android operating system that delivers online courses conformant with SCORM to learners’ mobile devices. Figure 10.1 presents an overview of ASK Mobile SCORM Player architecture and its different modules.

As shown in the figure, the SCORM course packages (in zip format), which can be developed by an online course designer using a SCORM Course Authoring tool, can be stored on a specific location in the learner’s mobile device. An unzip utility is then used for unpacking the educational resources of the online course to a specific location of the mobile device, so as to be retrievable by the user interface of the course player. The manifest XML file also included in the zip file of the course incorporates the structure of the course, as well as sequencing and navigation rules for the educational resources.

The manifest XML file is validated against SCORM v1.2 or SCORM 2004 and, after successful validation, it is parsed and processed by the sequencing and navigation mechanism. The user interface, according to the learner’s actions, sends requests to the sequencing and navigation mechanism and retrieves information about next or previous educational resources that can be presented to the learner. Finally, an internal database is used for storing information about learners’ course history. This means that learners can suspend the execution of an online course and continue at a later time from the specific educational resources they have previously stopped.

Figure 10.1: ASK Mobile SCORM Player architecture.



Main Functionalities

The ASK Mobile SCORM Player has the following functionalities (Kardaras, 2010):

- **Ability to import an online course:** The learner has the capability to import to the ASK Mobile SCORM Player several online courses in SCORM v1.2 or SCORM 2004 format, which are stored in a specific location of his or her mobile device (see Figure 10.2). The SCORM packages are unzipped and validated against SCORM v1.2 or SCORM 2004 before being added and become available for delivery via the ASK Mobile SCORM Player.
- **Ability to select and execute an online course:** After the successful import of SCORM course packages to the ASK Mobile SCORM Player, the learner is able to select and execute one of the imported online courses (see Figure 10.3). The ASK Mobile SCORM Player parses the manifest XML file of the SCORM course and dynamically creates the structure of the educational resources to be presented to the learner through the user interface.
- **Ability to navigate to educational resources of an online course:** The learner has the capability to navigate to the educational resources of a selected online course. After the presentation of an educational resource, a green tick will be added to this resource and other educational resources will become available for presentation (see Figure 10.4). Additionally, if the SCORM course package includes sequencing and navigation rules, it is possible for educational resources to be skipped or repeated (rollup rules). These sequencing and navigation rules are triggered based on a learner's choices and achievements during the execution of specific educational resources types such as quizzes and tests.

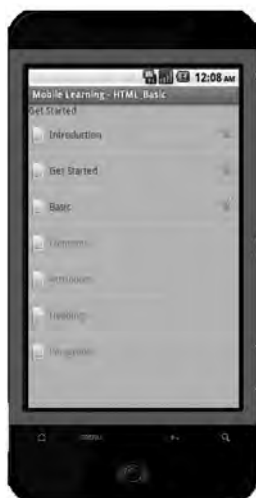
Figure 10.2: Import an online course.



Figure 10.3: Select and execute an online course.



Figure 10.4: Navigate and execute educational resources of an online course.



- **Ability to render different technical formats of educational resources:** The ASK Mobile SCORM Player has the capability to render HTML-based educational resources, as well as work with flash-based educational resources (see Figure 10.5).
- **Ability to suspend and resume an online course:** The learner has the capability to suspend an online course and resume it from the same educational resources at a later time (see Figure 10.6). As a result, the ASK Mobile SCORM Player records a learner's history related to the online courses that he or she has executed, so as to be able to continue or even repeat previously executed online courses.

Figure 10.5: Rendering HTML-based educational resources.



Figure 10.6: Resume an online course.



The ASK Mobile Learning Design Player (ASK Mobile LD Player)

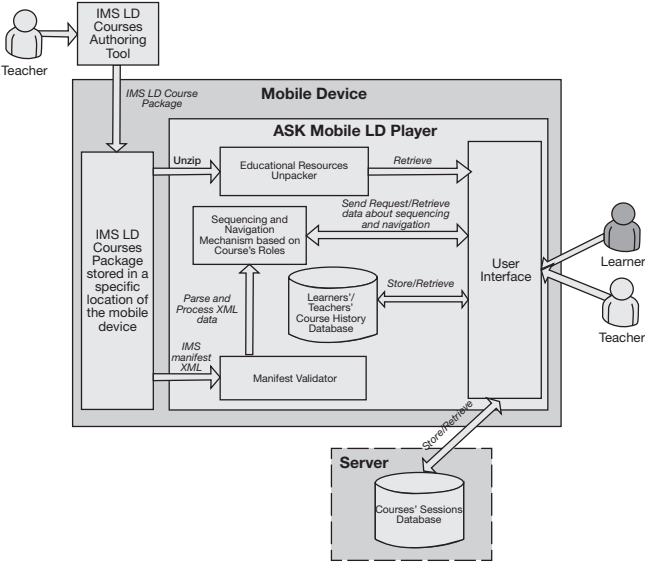
Overview and Architecture

The ASK Mobile Learning Design Player (ASK Mobile LD Player) is a native application suitable for mobile devices with an Android operating system that facilitates teachers and their learners in participating in online courses that conform with MS LD.

Figure 10.7 presents an overview of the ASK Mobile LD Player architecture and its different modules. As shown in Figure 10.7, IMS LD courses packages (in zip format), which can be developed by an online course designer using a IMS LD Course Authoring tool, can be stored at a specific location in the learner's and/or teacher's mobile device. Afterwards, an unzip utility is used for unpacking the educational resources of the learning activities of an online course to a specific location of the mobile device, so as to be retrievable by the user interface of the course player. The manifest XML file also included in the zip file of the course incorporates the structure of the course, as well as sequencing and navigation rules for the learning activities.

The manifest XML file is validated against the IMS LD, and after successful validation it is parsed and processed by the sequencing and navigation mechanism, which creates different learning activity flows based on the different roles that have been defined in the online course. The user interface, according to the selection of a specific role for participating in an online course, requests the appropriate learning activities flow from the sequencing and navigation mechanism. Moreover, according to the specific role actions, the user interface sends a request to the sequencing and navigation mechanism and retrieves information about next and/or previous learning activity that can be presented to the specific role (teacher or learner). Additionally, an internal database is used for storing information about learners' and teachers' course history. This means that learners and teachers can suspend the participation to an online course and continue at a later time from the specific learning activity that they have previously stopped. Finally, there is an external database located on an external server, which stores information about course sessions. This database is used to enable teacher and learner participation to be synchronised in online courses, facilitating execution of collaborative learning activities.

Figure 10.7: ASK Mobile LD Player architecture.



Main Functionalities

The ASK Mobile LD Player has the following functionalities (Sampson et al., 2007):

- **Ability to import an online course:** The user (that is, learner or teacher) has the capability to import to the ASK Mobile LD Player several online courses in IMS LD format, which are stored in a specific location of his or her mobile device (see Figure 10.8). The IMS LD packages are unzipped and validated against IMS LD before being added and become available for delivery via the ASK Mobile SCORM Player.
- **Ability to select and execute an online course:** After the successful import of IMS LD course packages to the ASK Mobile LD Player, the user is able to select and execute one of the imported online courses (see Figure 10.9). The ASK Mobile LD Player parses the manifest XML file of the IMS LD course and dynamically creates the structure of the learning activities to be presented to the user.
- **Ability to select the intended role for participating in an online course:** The user has the capability to select an appropriate role (from those defined within the selected online course) (see Figure 10.10). Depending on the selected intended role, the ASK Mobile LD Player will present him or her with different learning activities flows to be executed.

Figure 10.8: Import an online course.



Figure 10.9: Select and execute an online course.



Figure 10.10: Select a role for participating in an online course.



- **Ability to join or create an online course session:** The user has the following capabilities (see Figure 10.11): selecting a course session to join, to enable synchronisation between different users and to facilitate participation in collaborative learning activities with his or her peers (who participate in the same session, or with his or her teacher (who also participates in the same session); and creating a new course session, so that other users (learners or teachers) can participate in his or her session. A user cannot individually join any course session and execute the learning activities of an online course. The functionality of joining

or creating a course session requires an Internet connection. If there is no available Internet connection, the ASK Mobile LD Player suggests the user not join any course session but to execute the learning activities offline.

- **Ability to navigate to learning activities of an online course:** The learner has the capability to navigate to the learning activities of a selected online course. After the presentation of a learning activity, a white tick will be added to the activity and other learning activities will become available for presentation (see Figure 10.12). Additionally, if the IMS LD course package includes Level B sequencing and navigation rules, it is possible for learning activities to be skipped or repeated (rollup rules). These sequencing and navigation rules are triggered based on a learner's choices and achievements during the execution of specific learning activity types, such as assessment activities.

Figure 10.11: Join or create an online course session.



Figure 10.12: Navigate to the learning activities of an online course.



- **Ability to render different technical formats of educational resources:** The ASK Mobile LD Player has the capability to render HTML-based educational resources, as well as work with flash-based educational resources (see Figure 10.13).
- **Ability to suspend and resume an online course:** The learner has the capability to suspend an online course and resume it from the same learning activity at a later time (see Figure 10.14). As a result, the ASK Mobile LD Player records a user's history related to the online courses that he or she has executed, so as to be able to continue or even repeat previously executed online courses.

Figure 10.13: Rendering flash-based educational resources of the learning activities of an online course.



Figure 10.14: Resume an online course.



Conclusion and Future Work

Within the landscape of the ongoing standardisation efforts in the field of TEL, it seems that limited attention has been paid to the development of open-source mobile applications that aim to support TEL standards related to online courses design, packaging and delivery. Thus, in this chapter, the implementation of two open-source mobile course players that aim to facilitate the delivery of SCORM and IMS LD courses via mobile devices was presented. Table 10.2 compares the proposed mobile course players with other existing mLearning courses.

Table 10.2: Comparing ASK Mobile SCORM-player and ASK Mobile LD Player with existing mobile course players

Course player	Commercial	SCORM v1.2	SCORM 2004	IMS LD			Operating system
				Level A	Level B	Level C	
Upside Learning	Yes	✓	✓	-	-	-	iOS, Android
Litmos Mobile	Yes	✓	✓	-	-	-	iOS, Android
eXact Mobile	Yes	✓	✓	-	-	-	iOS, Android
Xyleme	Yes	✓	✓	-	-	-	iOS, Android
Intuition Mobile	Yes	✓	✓	-	-	-	iOS, Android
Rapid Intake	Yes	✓	✓	-	-	-	iOS, Android
Padiadpu (2008)	No (open source)	✓	✓ (partially)	-	-	-	Android
Zualkernan et al. (2009)	No (open source)	-	-	✓ (partially)	✓ (partially)	-	Android
ASK Mobile SCORM Player	No (open source)	✓	✓	-	-	-	Android
ASK Mobile LD Player	No (open source)	-	-	✓	✓	-	Android

As can be seen in Table 10.2, both the ASK Mobile SCORM Player and ASK Mobile LD Player overcome limitations of existing open-sources implementations and they can also be compared with commercial mobile course players. Our future work includes the development of context-aware mobile course players that aim to deliver adaptive and personalised online courses 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. An initial work towards this direction has been reported in Gómez, Zervas, Sampson, and Fabregat (2012), where a context-aware mobile course player has been developed. Based on IMS LD, it automatically adapts individual learning activities of an online course based on learners' contextual information.

Acknowledgements

The work presented in this paper has been supported by the MW-TELL Project (www.Mobile2Learn.eu) that is funded by the European Commission under the Leonardo da Vinci (LdV) Sectoral Programme of the Lifelong Learning Programme (Contract No: 2008-1-GR1-LEO05-00693).

References

- Alves, P., & Uhomobhi, J. (2010). Issues of e-learning standards and identity management for mobility and collaboration in higher education. *Campus-Wide Information Systems*, 27, 79–90.
- Bush, M. D., Walker, E. C. T., & Sorensen, A. N. (2011). E-learning standards: SCORM and the future of interoperability. *Educational Technology*, 51(5), 20–24.
- Cobcroft, R., Towers, S., Smith, J., & Axel, B. (2006). Mobile learning in review: Opportunities and challenges for learners, teachers, and institutions. *Proceedings of the Online Learning and Teaching Conference*, Brisbane, Australia.
- Devedzic, V., Jovanovic, J., & Gasevic, D. (2007). The pragmatics of current e-learning standards. *IEEE Internet Computing*, 11(3), 19–27.
- Dodds, P., & Thropp, S. E. (2006). Sharable Content Object Reference Model (SCORM) 2004. 3rd ed., Version 1.0, *Advanced Distributed Learning*.
- Gómez, S., Zervas, P., Sampson, D., & Fabregat, R. (2012). Delivering adaptive and context-aware educational scenarios via mobile devices. *Proceedings of the 12th IEEE International Conference on Advanced Learning Technologies (ICALT 2012)*, Rome, Italy, IEEE Computer Society.
- Gonzalez-Barbone, V., & Anido-Rifon, L. (2008). Creating the first SCORM Object. *Computers & Education*, 51(4), 1634–1647.
- Herrington, J., Herrington, A., Mantei, J., Olney, I., & Ferry, B. (2009). Using mobile technologies to develop new ways of teaching and learning. In J. Herrington, A. Herrington, J. Mantei, I. Olney, & B. Ferry (Eds.), *New technologies, new pedagogies: Mobile learning in higher education*. Wollongong, NSW: Faculty of Education, University of Wollongong.

- IMS Global Learning Consortium (GLC) (2003). IMS Learning Design Specification Version 1.0. Retrieved October 26, 2012, from www.imsglobal.org/learningdesign/
- Jeng, Y.-L., Wu, T.-T., Huang, Y.-M., Tan, Q., & Yang, S. J. H. (2010). The add-on impact of mobile applications in learning strategies: A review study. *Educational Technology & Society*, 13(3), 3–11.
- Johnson, L., Levine, A., & Smith, R. (2009). *The 2009 horizon report*. Austin, Texas: The New Media Consortium.
- Kardaras, V. (2010). *A SCORM-based mobile course player for the Google Android platform*, Master's thesis [in Greek], Department of Digital Systems, University of Piraeus. Retrieved October 26, 2012, from <http://digilib.lib.unipi.gr/dspace/handle/unipi/3551>
- Koper, R., & Burgos, D. (2005). Developing advanced units of learning using IMS Learning Design level B. *International Journal on Advanced Technology for Learning*, 2 (3), 252–259.
- Koper, R., & Olivier, B. (2004). Representing the learning design of units of learning. *Educational Technology & Society*, 7(3), 97–111.
- Kukulska-Hulme, A. (2009). Practitioners as innovators: Emergent practice in personal mobile teaching, learning, work, and leisure. In M. Ally (Ed.), *Mobile learning: Transforming the delivery of education and training* (pp. 135–155). Edmonton, AB: Athabasca University Press.
- Lu, E.J.-L., & Chen, Y.-H. (2006). Design of a delegable SCORM conformant learning management system. *Journal of Computer Assisted Learning*, 22(6), 423–36.
- Padiadpu, R. (2008). *Towards mobile learning: A SCORM Player for the Google Android platform*. Master's thesis, Hamburg University of Applied Science, Information Engineering.
- Qu, K., & He, W. (2009). SCORM versus IMS-LD: Discussion on development trends of e-Learning. *Proceedings of the International Conference on Computational Intelligence and Software Engineering* (CiSE 2009), Wuhan, China, 11–13 December 2009.
- Sampson, D., Götze, K., & Zervas, P. (2007). Delivering IMS learning design activities via mobile devices. *Proceedings of the 7th IEEE International Conference on Advanced Learning Technologies* (ICALT 2007) (pp. 367–368), Niigata, Japan, IEEE Computer Society.
- Sanchez-Alonso S., Lopez, M. G. & Frosch-Wilke, D. (2011). E-learning standards for content management. In F. Núria Ferran & A. Julià Minguillón (Eds.), *Content Management for E-Learning* (pp. 131–156). New York: Springer.
- Sharples, M. & Roschelle, J. (2010). Guest editorial: Special issue on mobile and ubiquitous technologies for learning. *IEEE Transactions on Learning Technologies*, 3(1), 4–5.
- Traxler, J. (2009). Current state of mobile learning. In M. Ally (Ed.), *Mobile learning: Transforming the delivery of education and training* (pp. 9–24). Edmonton, AB: Athabasca University Press.

- Varlamis, I., & Apostolakis, I. (2006). Present and future of standards for e-Learning technologies. *Interdisciplinary Journal of Knowledge and Learning Objects*, 2, 59–76.
- Zatarain-Cabada, R., Barrón-Estrada, M. L., Sandoval-Sánchez, G., Urías-Barrientos, E., Osorio-Velásquez, M., & Reyes-García, C. A. (2009). EDUCA: A Web 2.0 collaborative, mobile and e-learning authoring system. In *Proceedings of the 9th IEEE International Conference on Advanced Learning Technologies* (ICALT 2009) (pp. 287–289), 15–17 July 2009, Riga, Latvia.
- Zuolkernan, I. A., Nikkhah, S. & Al-Sabah, M. (2009). A lightweight distributed implementation of IMS LD on Google's Android platform. In *Proceedings of the 9th IEEE International Conference on Advanced Learning Technologies* (ICALT 2009) (pp. 59–63), 15–17 July 2009, Riga, Latvia.

Mobile Learning Operating Systems

Christian Glahn

Abstract

Scalable mobile learning (mLearning) solutions depend on mLearning operating systems. These systems are information systems that provide the technological underpinning of applications that support educational programmes. Mobile learning operating systems can be separated into learning management and learning orchestration systems. This chapter describes the common characteristics of these systems and discusses how the systems can be used to design new and advance existing solutions for mLearning. By addressing the systematic limitations of present systems and standards and analysing available prototype solutions, the chapter illustrates the novel requirements for, and principles of, future information system infrastructures that can support a wide range of educational scenarios within changing arrangements of available technologies.

Introduction

Scalable mobile learning (mLearning) solutions cannot rely on custom-tailored and single-purpose applications. Rather, these solutions require underlying operating systems for managing and orchestrating educational programmes. This chapter refers to a class of operating systems that bring mLearning to practice. Mobile learning operating systems provide the technical underpinning and structure for educational applications. The common characteristics of mLearning operating systems are described and their use for designing and advancing solutions for mLearning are discussed. One important question in this context asks for what the differences are between mLearning and other types of technology-enhanced learning and how these differences influence the design of scalable educational technology. The challenge for educational information

systems is not limited to technical aspects; aspects of educational design must be considered too. This chapter therefore analyses different system approaches to mLearning systems from the viewpoint of a theory model of educational design inspired by activity.

In order to understand the specifics of mLearning operating systems compared with conventional virtual learning environments (VLEs), it is necessary to highlight the significant difference between mLearning and other forms of generic educational technologies. Mobile learning can be characterised as the processes (personal and public) of “coming to know” through exploration and conversation across multiple contexts and amongst people and interactive technologies (Sharples et al., 2007). This definition avoids mentioning portable devices while it highlights the relevance of context as a key educational dimension that is specific to mLearning. This raises the question about the role of context and the implications for the design and development of scalable solutions for operating mLearning.

This chapter has four parts. The first part analyses the characteristics and differences of mLearning operation systems based on an extended activity theory model. The second part focuses on the new requirements to learning management systems for supporting mobile learners. The third part analyses modelling concepts and system architectures for orchestrating mLearning solutions. This part specifically highlights the limitations of the present educational technology standards with regard to mLearning and proposes a contextualisation system architecture. Finally, the chapter validates the concepts with selected system designs from the literature. These examples include location-based and anchored instruction, simulated augmented experiences, and multidevice learning environments.

Learning Management and Orchestration

Mobile learning operating systems can be separated into mLearning management and orchestration systems. The term “learning management systems” (LMSs) is widely used in the context of Web-based and blended learning scenarios, while learning orchestration systems have not received much attention as an independent type of system. This chapter touches on many aspects that are specific to each system type.

LMSs are designed to support the administration tasks of educational processes. These tasks include, but are not limited to, the distribution of learning material and course information, online assessment, student and grade management, the collection of student assignments, and access to educational tools (e.g., discussion forums). Most LMSs are designed around the concept of a unit of learning that is also referred to as a “course.” LMSs are sometimes called virtual learning environments because learners use the tools provided by these systems for achieving their learning objectives. Typically, LMSs are educationally neutral because they emphasise administrative tasks and the access to tools that are necessary for a learning activity. The relation of tool usage and the achievement of learning objectives are left to a moderator, tutor or instructor.

Learning orchestration systems extend the function of LMSs by providing the means for supporting educational processes and learning models. A learning orchestration system connects learning objectives, learning activities, and

learning outcomes throughout the educational process phases. These processes not only include learning activities, but also support activities that describe common educational interventions. Based on educational process descriptions, learning orchestration systems can support learning processes that range from unsupervised individual learning and assessment scenarios to asynchronous multi-user environments, in which educators monitor the progress of individual learners in asynchronous processes. Examples of learning orchestration systems are the run-time engines for SCORM 2004 (ADL, 2009) or for IMS Learning Design (Koper, Olivier, & Anderson, 2003).

The main difference between LMSs and learning orchestration systems is that the structure of learning processes is implicitly defined and handled in learning management systems, while learning orchestration systems rely on explicit models of learning processes. The functions of the two system types are supplementary. Consequently, in the context of this chapter, a learning orchestration system comprises an LMS and a process control component.

By considering the mobility of learners as key aspects of learning management and orchestration systems, the perspective for designing these system changes and has to take into account concepts that were not primarily relevant to conventional desktop-oriented systems. Three overarching concepts were identified as specific to mLearning (Börner, Glahn, Stoyanov, Kalz, & Specht, 2010):

1. Access to learning
2. Context of learning
3. Orchestration of learning in and across contexts

These concepts create new requirements for the usability and the architecture of systems and infrastructures for learning management and learning orchestration.

Activity Theory Approach to System and Instructional Design

Engeström's activity theory (1996) is a systemic approach to analysing activities and processes in relation to their outcomes. The underpinning concept extends the behaviouristic perspective of cause and effect in order to describe human behaviour sufficiently. The outcome of a task is constrained by several factors that go beyond the behaviouristic output-centred perspective. In order to describe complex processes and labour appropriately, Engeström (1999) proposes a holistic model for analysing and describing activities in relation to their outcomes. This model has been applied in the design of complex systems, business processes and interactive computer systems.

Engeström's activity model presumes that every activity is part of and constrained by social practice (Engeström, 1999) and can be described by the following six factors:

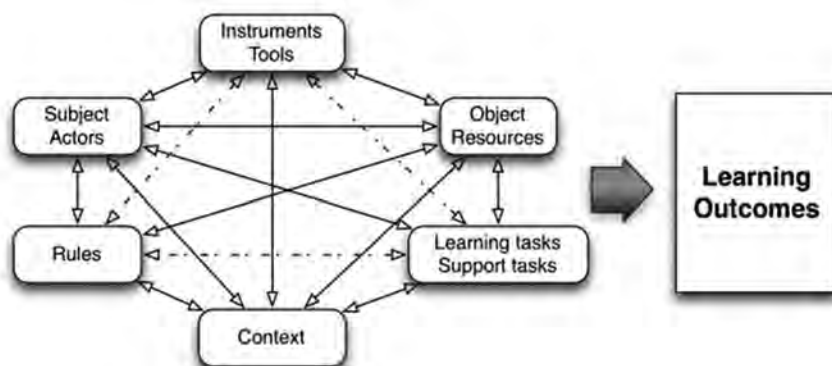
1. The actors (or subjects) who perform a task that is part of the activity.
2. The resources (or objects) that are used during the task and lead to the outcome.
3. The instruments and tools that are used by the actors to work with the resources.

4. The rules that constrain how actors can use the resources.
5. A “community” that contextualises the activity and defines what are socially acceptable and desirable uses of resources, tools and rules.
6. Tasks (or “division of labour”) that relate to the different steps of an activity and define the process of an activity.

In the original model, “community” is the only contextualising factor for an activity. Lave (1993) has highlighted that “community” is only one type of context among six context types that influence learning. In order to generalise the model, the “community” of Engeström’s original model is replaced by the more generic term “context” in order to emphasise that not only social practice situates professional and educational activity (Lave and Wenger, 1991; Wenger, 1998).

Engeström’s activity theory model considers “instruments” and tools as passive components that are used by the actors to work with the resources. However, contemporary ICT includes active tools that can push affordances to the actors. This active role is not represented in the original model. The new affordances create previously unconsidered systemic dependencies between rules and tasks on the one side and the tools on the other. As tasks are no longer mediated by the actors’ behaviour, by contextual dependencies or by resources, it is also necessary to represent the rules that constrain externally initiated affordances of tasks (see Figure 11.1). This extended system model of activity theory is referred to as the “activity system model” throughout this chapter.

Figure 11.1: Activity system model adapted from Engeström (1999) (the dashed lines indicate the extensions).

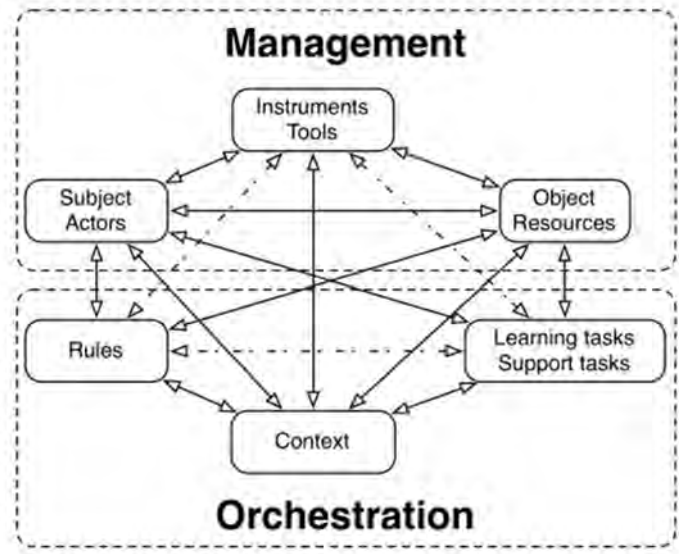


Instructional design theories consider similar elements for modelling educational processes. In addition to the activity-outcome relation, instructional design concepts consider additional framing conditions (Dick, Carey, & Carey, 2009; Reigeluth, 2009). For example, these conditions are prerequisites or learning objectives. These conditions are not part of the activity itself or define the outcomes. The framing of learning activities is typically presented as constant throughout the activity, while tasks and rules for task arrangement represent the dynamics aspects of learning and instruction. Two types of tasks can be identified:

1. The learning tasks that are performed by the learners.
2. The support or scaffolding tasks that are performed by teachers, tutors or moderators.

From the viewpoint of the activity system model, LMSs primarily focus on co-ordinating actors, providing them access to the relevant resources, and arranging the appropriate tools. Learning orchestration systems focus on supporting learning processes by arranging learning tasks, following appropriate rules, and monitoring the tasks. Figure 11.2 illustrates the relation of learning management systems and learning orchestration systems in relation to the activity system model.

Figure 11.2: Management and orchestration factors of an activity.



Many conventional instructional design concepts consider most context dimensions as framing conditions that define the learning environment. However, mLearning stresses the relevance of context for the dynamics of learning. The primary contextualising factors of a learning activity may change during the activity and reshape the possible tasks, the way in which tools and resources can be used, or the available actors. These changes can be part of the design of the learning activity, initiated by the mobility of the learner, or caused by external factors. While the perspective of a learning activity’s contextual framing would consider such dynamic changes as outliers or erratic, mLearning considers them as normal or even as essential parts of the learning experience. This has implications for designing both learning management and learning orchestration systems.

Learning Management: Resources, Tools and Actors in Context

Reigeluth (1983, p. 8) defines instructional management as being “concerned with understanding, improving, and applying methods of managing the use of an implemented instructional program.” Instructional management prescribes optimal timelines or time slots, data-collecting procedures, learner enrolment, grading processes, the access to tools and instruments, the delivery of educational material, and so on. Learning management systems support educators in managing educational processes by providing standardised tools and procedures for common tasks.

The previous section pointed out that LMSs do not directly consider context. Yet, context dimensions influence the design of LMSs because learners and educators have different ways and needs for co-ordinating and accessing their

learning processes. From this viewpoint, mLearning management supports a broader variety of access to learning opportunities. Consequently, mLearning management primarily considers the systems' accessibility and usability.

In the past, LMSs were mostly optimised for desktop computing environments by presuming a minimum screen size through which the system is accessed. In Web-based learning environments, the smallest common denominator of the available browser functions determines how remote systems can be accessed and used. This approach presumes that the technology which was used to access the systems had mostly similar functions and structures. This "interaction context" of a learning activity was considered as stable due to missing technical alternatives for accessing these systems. With the advent of Internet-capable personal digital assistants (PDAs) and smartphones, it became evident that the common denominator approach is inappropriate if mobile devices are included in the equation. Despite the obvious differences in screen sizes, most mobile devices follow different interaction principles than desktop computing environments.

With the recent versions of HTML and JavaScript, it is possible to support the special interaction principles of mobile devices. Most mobile devices already support these new Web technologies, and many Web-based LMSs take advantage of these capabilities and provide alternative user interfaces for mobile users. Although the approach of "responsive" Web design allows user interfaces that adapt to the device capabilities, it is common practice to develop independent user interfaces for mobile access and for desktop environments. This approach provides convenient access to the functions of an LMS for users with mobile devices.

Providing users an adapted user interface that follows the interaction logic of the LMS has the benefit that all users have access to the same functions. However, mLearning management depends on more contextual factors than the interaction context. Most notable is the connectivity for mobile users. While in desktop contexts, connectivity to the LMS is typically assumed to be continuous, this assumption does not hold for mobile users. The common impression of mobile users is that they are "always on" and "always online." The first characteristic refers to the fact that many people do not switch off their mobile device unless the battery runs out. The second characteristic refers to the impression that mobile devices can always connect to online services. Despite this common impression, the actual online state of mobile users is best described as randomly online. Being randomly online refers to the changing state of wireless network connectivity.

For randomly online users, the connection state is unpredictable. Therefore, LMSs must not make any assumptions about the connection state of the learner. Mobile devices automatically select the "best" wireless connection for data traffic. Due to user movements or to changing environmental conditions, users may switch network connections or be temporarily offline within a single interactive session. Randomly online users will experience disruptions to their learning if the related LMS assumes that learners will be continuously online during their interaction. In the best case, these disruptions cause minor annoyances (e.g., if users have to reload resources several times before they can access them). In the worst case, significant interruptions of the learning process can cause a loss of learning outcomes (e.g., if a learner is unable to submit the test results because network interruptions exceeded the submission deadlines).

A mobile LMS has to be agnostic regarding its users' connection states and provide appropriate measures to avoid disruptions to educational and learning processes. In order to achieve a continuous user experience, an LMS needs to offload parts of its functions to the users device. This allows the user to access system functionalities regardless of his or her connection state. This creates the challenge of synchronising data between the central LMS and its mobile clients. The straightforward approach of user-initiated synchronisation should be avoided. The primary reason for this is that if users forget to refresh, they may work with outdated information.

There are two cases for data synchronisation. The first case is given if synchronisation becomes necessary due to changes in the central LMS (server-side changes). The second case is given if the device needs to report user-generated data back to the central LMS (client-side changes).

Server-side changes can be synchronised either by the client systems testing for updates on the server, or by the server system notifying the connected clients about changes. The former approach is also called a “pull approach” and is more suitable for frequently changing data and active users. The latter approach is referred to as “push notifications” and is more suitable for infrequently changing data or infrequently used systems. The main benefit of push notifications is that the client devices can receive them even if the device is not active.

Client-side changes are typically related to user interactions. For LMSs, it is important that no relevant information is lost. Therefore, it is important that mobile clients of LMSs are responsive to the connection state of their clients. A reliable approach is to cache pending synchronisation states while the device has no data connection. This also includes the case if the connection has been lost during a data transfer.

The principles of randomly online users have been implemented in the mobile flashcard learning application “Mobler Cards” (Glahn, Mitsopoulou, Nake, & Wendel, 2012) that integrates with a LMS. This smartphone application synchronises course-related learning resources for self-practice from the LMS to the learner's smartphone in order to provide access to the learning material regardless of the connection state of the learner's device. The learning performance is analysed by the application and synchronised with the LMS so that instructors can provide support tailored to the learner's performance in the course. The application is specifically designed to support not only occasional, but also extended, offline periods of the learner.

Learning Orchestration: Contextualising Learning with Rules, Tasks and Environments

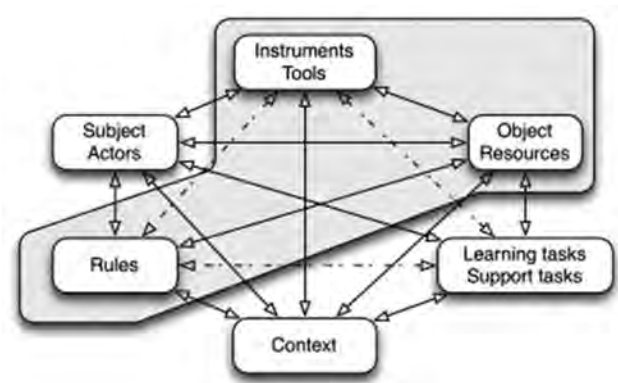
While LMSs support the organisational tasks that are related to educational and learning processes, learning orchestration systems support the implementation of educational designs. From the viewpoint of the activity system, model learning orchestration systems are directly related to the procedural factors of learning activities: rules, task and contexts.

A basic learning orchestration system relies on a process model that defines task sequences based on a set of rules within a learning environment. The rules can be related to learner performance, learner characteristics or learner preferences. Such

models arrange how the actors in a learning process have access to the available instruments and resources. These process models are typically referred to as instructional or educational designs. Currently, two specifications are available for providing and exchanging process models between learning orchestration systems: IMS Simple Sequencing (Norton & Panar, 2003) and IMS Learning Design (Koper et al., 2003).

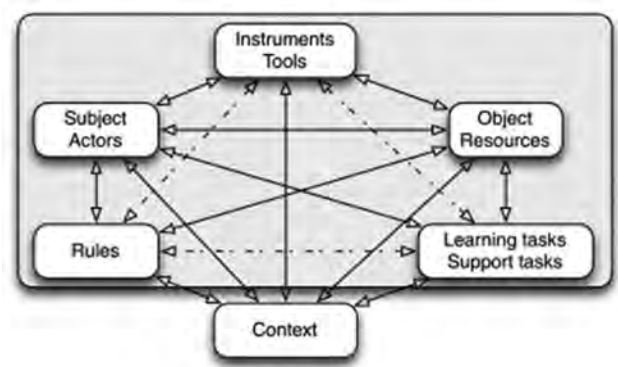
The IMS Simple Sequencing specification defines the semantics to describe process models for individual learning that can be interpreted by SCORM 2004 run-time environments (ADL Initiative, 2009). IMS Simple Sequencing provides no explicit representation of different actors in the activity. Figure 11.3 illustrates the relation of IMS Simple Sequencing constructs to the activity system model.

Figure 11.3: Focus of IMS Simple Sequencing in relation to the activity system model.



A more generic approach is provided by the IMS Learning Design specification. This specification defines high-level process models based on roles, resources, services, activities and conditions. In the semantics of IMS Learning Design, “activities” refers to tasks in which actors are exposed to selected resources and instruments. Through conditions it is possible to arrange the tasks into processes. Additionally, IMS Learning Design provides the “environment” construct that allows resources and instruments to be combined in order to be re-used across different tasks. An IMS Learning Design environment implies data persistence across the tasks to which the environment is connected. As such, the environment construct refers to a rudimentary learning context. Figure 11.4 illustrates the relation of IMS Learning Design concepts in relation to the activity system model.

Figure 11.4: Focus of IMS Learning Design in relation to the activity system model.

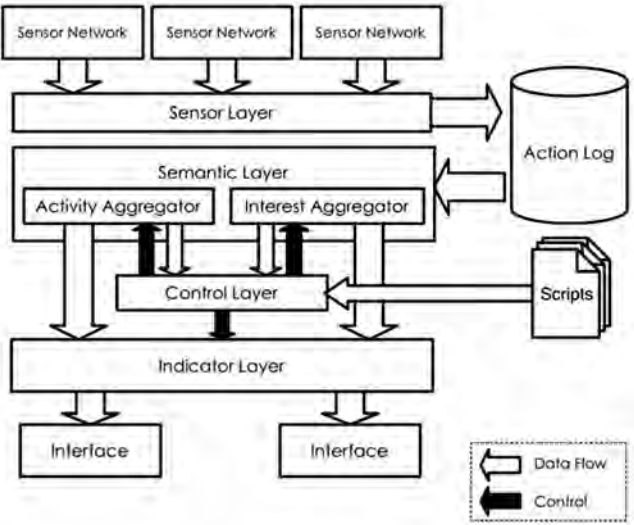


The conditional frameworks of IMS Simple Sequencing and IMS Learning Design are based on explicitly modelled user interactions with resources or instruments of the associated learning management component. In both cases, contextual factors are considered as framing the learning activity and cannot influence the flow of educational processes. As mLearning scenarios reflect learning in and across contexts, context factors are no longer framing learning activities but are structuring components of learning processes. This has two important implications for mLearning orchestration and challenges the design of mLearning orchestration systems:

1. Contextualising factors of the learning environment need to be considered as structuring components of learning processes.
2. Learning processes are no longer influenced only by direct interactions with the supporting learning orchestration system but also by factors that are emerging from the dynamics of the learners' mobility.

To tackle these challenges, the actuator-indicator architecture has been proposed as a generic attempt for designing and developing context-aware systems (Zimmermann, Specht, & Lorenz, 2005). This architecture has been proven to be practically relevant for building context-aware and context-responsive systems for different educational settings (De Jong, Specht, & Koper, 2008; Florian, Glahn, Drachsler, Specht, & Fabregat, 2011; Glahn & Specht, 2010; Glahn, Specht, & Koper, 2008). The architecture allows conceptualising the different phases of data processing for context-aware interactive systems using four primary layers: the sensor layer, the semantic layer, the actuator layer and the indicator layer (see Figure 11.5).

Figure 11.5: Core components of the actuator-indicator architecture (Glahn, 2009).



The sensor layer defines the ways in which actors can interact with the system. As in mLearning scenarios, interactions can be explicit by interacting with a user interface on a device or implicit by performing in an environment. These sensors form a “sensor network” that allows combining the data from these sensors for creating richer information. Larger sensor networks can span physical space, such as movement sensors in a building, and even extend to a global scale such as

tsunami warning systems. The sensor layer defines a sensor network that captures explicit and implicit interactions within a learning environment.

The simplest sensor networks are built directly into mobile devices. For example, recent smartphones provide the following sensors:

- microphone
- camera
- GPS receiver
- compass
- proximity sensor
- accelerometer
- touch-sensitive surface (touchscreen)

The semantic layer collects the data provided by the sensor network and processes this data into higher-level information. This processing is also called “data aggregation.” An aggregator is a function that transforms sensor data into semantically meaningful information. The aggregation of sensor information can identify traces of activities. For example, a GPS receiver provides the current location of the device. By aggregating a sequence of locations, it is possible to determine movements and the orientation of a device. If the time of location measurement is also known, an aggregator can also provide information about how fast a device has travelled. In the context of technology-enhanced learning, the definition of appropriate aggregators is the subject of the research on learning analytics.

The actuator layer uses the semantic information of one or more aggregators for determining the state of a process and for activating system behaviour accordingly. This layer controls the behaviour of a context-aware system by applying different strategies. A strategy defines the system behaviour under certain conditions. These conditions include activation and termination rules for a strategy. Strategies can be predefined or automatically generated by the system. A set of predefined strategies is also called a script, such as an educational design.

The indicator layer provides human interpretable interfaces that reflect the system behaviour. The actuator layer controls the information that is presented by the indicator layer. The indicator layer is subject primarily to user interface design and system usability.

System Design for Mobile Learning

Mobile instructional designs for learning orchestration systems need to consider the different facets of context-sensitive data processing in order to guide learning processes in and across contexts.

- At the level of the sensor layer, it is important to decide which sensor network should be used for defining the contextual cues of the learning activity. This helps with considering the benefits, constraints and limitations of the sensors for the given learning scenario. Sometimes sensors cannot be used in a learning scenario or their use is legally restricted. Consequently, it is also useful to identify alternative sensor networks as a fall-back solution.

- At the level of the semantic layer, it is necessary to define the storage format for the sensor data and the intended use of the sensor data. The storage format defines which aggregation types can be efficiently performed. The intended use of the aggregated information includes answering the question if the indicator layer, the actuator layer or both layers should use the information. Some aggregations might be legally or ethically constrained, especially if they include the exposure of peer information. Previous research (Florian, Glahn, Drachsler, Specht, & Fabregat, 2011; Verpoorten et al., 2009) has suggested the concept of social planes for limiting the access to peer information.
- At the level of the actuator layer, the educational design defines the impact of the aggregated sensor information on the flow of a learning process. At this level, the process model needs to reflect whether an actor's task initiated while being actively involved in the process, or whether a contextual factor changed the conditions of the process.
- At the level of the indicator layer, the educational design needs to consider how the learners are guided into the learning processes. The dynamics of learning processes are important, because some changes might result from implicit system interactions. In turn, this could result in learners remaining unaware that changes have occurred in their learning environment. Therefore, the indicator layer of mLearning orchestration systems needs to provide cues for drawing the learners' attention to a learning opportunity and means for identifying whether learners have taken up this opportunity.

The following scenarios illustrate different approaches to mLearning orchestrating systems from the viewpoint of the architecture and of the activity system model.

Location-based and Anchored Instruction

It has been argued that location-based learning and the closely related concept “anchored instruction” are ideal applications for mLearning (De Jong et al., 2008). The characteristic of this type of learning and instruction is that the learning process is guided by the context factors of the learning environment. In the case of location-based learning, a learner needs to be in predefined locations in order to access the learning opportunities. The more generic concept of anchored instruction is not restricted to a single context factor, but can be anchored to any factor or even combinations of context factors.

Chu, Hwang, Tsai, and Tseng (2010) describe a learning orchestration system that guides learners through a biology learning activity in a school garden using “learning stations.” Each learning station is related to a specific learning task that is accessible when the user is in the correct location. After completing the task, the learners were asked to identify a matching location and go to the location in order to verify that they correctly identified similarities between the objects at the stations.

The study describes a two-step activity sequence comprising an identification task and a match-making task. In case the learner did not complete the first task correctly, an additional comparing task was injected for helping the learner identify the correct answer. The task that is available at a certain location is determined by the learners' trajectory using the following rules.

- If the learner has not started the identification task, present identification task.
- If the learner has completed the identification task with a correct response, present the match-making task.
- If the learner has completed the identification task with an incorrect response, present the comparing task.
- If the learner has completed the comparing task with a correct response, present the match-making task.

To determine the location of the learner, “quick response” (QR) tags were used. With the QR tag, it is possible to determine the location of a learner in the school’s garden. To access QR tags, the learners needed to use the device’s built-in camera as a sensor. Alternative location sensors are GPS or wireless triangulation. However, the accuracy of these sensors is typically around 7 metres (21 feet) for commercial mobile devices. In the dense set-up of learning stations in a school garden, GPS would not have been sufficient for discriminating learners at nearby learning stations. Alternatively, radio-frequency (RFID or NFC) tags could have served as direct replacements without changing the set-up. The related reading devices were not available at reasonable costs for the study.

The aggregation function interprets the QR code and reports whether the learner is at the appropriate location. Whenever a learner checks a location tag, the actuator layer applies the process rules in order to determine which information to present to the learner. The indicator layer simply displays the task description.

De Vries, Ternier, and Visser (2010) presented a location-based mLearning system for field trips that has been used in the context of art history courses. The system is designed for hands-free mode so that students do not need to constantly pay attention to their smartphones. FitzGerald, Sharples, Jones, and Priestnall (2011) described similar systems.

Similar to the location-based learning scenario, learning opportunities were connected to point of interest. The students’ location was identified by GPS signals. The instructor provided personal assignments for the different locations. The system relies on a single orchestration rule: if the learner has not completed the assignment at the location, then the assignment needs to be presented to the learner.

The system uses the GPS receiver of the students’ smartphones for determining their location. Being designed for outdoor field trips in which the points of interest are relatively far apart from each other, the accuracy of the GPS signal was sufficient to discriminate the location of the learners. Alternative tag-based positioning using QR codes or RFID tags was not possible because these tags could not be placed in public locations at a reasonable cost. The semantic layer tests whether a student is in close proximity with a point of interest. The actuator layer activates the assignment for the current point of interest. The indicator layer triggers an acoustic signal if a student comes into the proximity of a point of interest with an uncompleted assignment. This acoustic signal should alert the students that they are entering a learning location. If the students decide to respond to the signal, the system presents the assignment information to them.

Simulated Augmented Experiences

Simulated augmented experiences are simulations that are embedded in spatial environments by using authentic communication modes. Unlike augmented reality, simulated augmented experiences do not create overlays of virtual and physical space. Instead, the spatial environment is used for enacting the simulation like a stage in a role-play.

Ternier, Gonslaves, de Vries, and Specht (2012) describe a system for training response teams to handle hostage-taking situations. The system guides a team of learners through an educational script by using text-notifications and audio messages. Each team needs to respond to the changing situations and challenges by distributing tasks and jointly creating artefacts such as plans, press releases or negotiation strategies.

The rules of the script describe sequences and dependencies between events and responses. The tasks of the learning activity follow regulations and guidelines for handling these situations. Other tasks include assignments that require creative responses by the team. These assignments are provided through text or voice messages that are sent to the learners. The systems also use context-based triggers for tasks. For example, it is possible to define tasks that become available if all team members are assembled in one room.

Each task can have different triggers. These triggers can be based on user-explicit interactions, by implicit interactions with the environment, or by external factors. In order to capture these triggers, the system captures user interactions and other aspects that influence the process flow at the actuator layer.

The framework provides orchestration support for trainers via a monitoring function. This feature aggregates the team's performance so a trainer can analyse the quality of the learning experience. While orchestration scripts define the generic flow of a training session on the level of the actuator layer, a trainer can inject new tasks or escalate the difficulty of the overall activity if suited.

The indicator layer for simulated augmented experiences relies on authentic communication modes. This requires resources that are suited for text messaging or for voice communication on mobile phones. These resources also provide clues on the expected tasks.

Multi-Device Environments

Multi-device learning environments refer to those environments in which learners use several devices while being active in a learning environment. The concept has been inspired by Weiser's (1991) vision of ubiquitous computing and is based on the observation that students are increasingly equipped with multiple devices. Learners work in such environments within a persistent information space, regardless of the device they currently use. Multi-device environments challenge mLearning orchestration systems because the interactions with one device may affect the information provided by other devices.

Glahn and Specht (2010) discuss a multi-device learning orchestration framework for the Moodle LMS. It has been designed to support the distribution of learning resources to appropriate interfaces, if they are available and accessible to the

learner, or to provide shared working spaces for group work if learners are present in the same room.

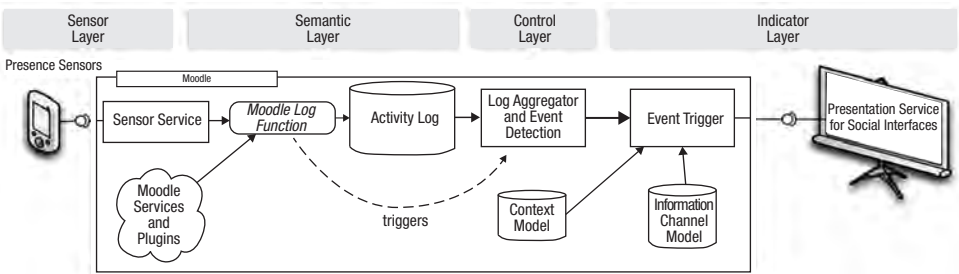
The framework uses Moodle’s LMS capabilities for storing and distributing information. It does not explicitly implement a sensor layer. Rather, it provides a data collection service that allows external sensor networks to be connected to Moodle and the data stored in Moodle’s native action log. This has the benefit that data from external sensors can be aggregated with the learner tracking of the Web-based system from a single source.

The actuator layer of the system relies on a context model. This model represents which devices are available in an environment so they can be used as instruments for providing resources to the learner. Furthermore, the model contains the defining parameters of an environment. These parameters include the sensors and the framing values that are used to determine the presence of learners in the environment.

The indicator layer consists of different tools and services that allow connecting to the LMS and providing interfaces to different instruments. The challenge at this level is to enable the device services requesting user-restricted information from the LMS, although the learners did not or even cannot authorise the device directly. This challenge has been solved through the token authentication of the OAuth protocol (Hardt, 2012). However, instead of connecting a token to a user session, the token is connected to the environment. If the context of the environment changes, the system revokes the token and, if necessary, issues a new token that represents the new condition state. These changes to the environment’s context occur, for example, if a second learner enters a room or if another learner leaves it.

The second challenge is device orchestration because the interaction design of Moodle was tailored for explicit interactions with the system through a single interface. For this interaction type, changes of the learning context can be detected as part of the normal interaction with the system. Device and process orchestration becomes challenging if implicit interactions with the learning environment occur. This can happen if external sensors, such as a room-mounted presence sensor, submit data to the LMS. In order to create a responsive learning environment, it is important to recognise context changes from implicit interactions with time. Therefore, the aggregator layer notifies the actuator layer if data has been received that might change the state of one or more contexts. Figure 11.6 shows the architecture of the system.

Figure 11.6: Actuator-indicator architecture translation for UbiMoodle (adapted from Glahn & Specht, 2010).



Conclusion

This chapter analysed the characteristics of mLearning operating systems compared with other approaches of technology-enhanced learning. Two types of systems can be distinguished for operating mLearning: mLearning management systems and mLearning orchestration systems. Both system types need to implement features for supporting the variability of the learning context.

Mobile learning management focuses primarily on managing learning resources, tools and actors in the learning process. This type of information systems is very similar to its conventional Web-based counterparts, but they rely on different contextual assumptions, specifically regarding the connection and learning context. Existing learning management solutions can easily integrate these characteristics for better support of the learners' mobility.

Mobile learning orchestration addresses the co-ordination of learning processes based on rules, tasks and contexts. The main difference between these systems and their Web-based counterparts is that the learning context can no longer be presumed as constant but as a dynamic factor of learning processes. The chapter discussed a generic system architecture for context-aware and context-responsive learning orchestration. Selected examples from the available literature illustrate the application for this system architecture for location-based and anchored instruction, simulated augmented experiences, and multi-device learning environments.

The analysis in this chapter shows that context needs to be considered already during design of learning activities. In order to reflect context factors for mLearning solutions, it is necessary to model the characteristics of mLearning contexts as part of the educational design. Currently, educational designers need to consider all aspects of this modelling process because of missing interoperability standards, as they are present for Web-based learning. Here lies the biggest challenge for scaling up and sustaining mLearning practice: a technical infrastructure needs to support educational practitioners so they can build and extend contextual models and integrate these models into the structures of educational processes. Research has to identify and categorise patterns for sensor networks and semantically meaningful aggregators in order to consider them for process control and system usability.

References

- Advanced Distributed Learning (ADL) Initiative (2009). Sharable content object reference model (SCORM) 2004. (4th ed. run-time environment, Version 1.1). Alexandria, VA: ADL Initiative.
- Börner, D., Glahn, C., Stoyanov, S., Kalz, M., & Specht, M. (2010). Expert concept mapping study on mobile learning. *Campus-Wide Information Systems*, 27(4), 240–253.
- Chu, H.-C., Hwang, G.-J., Tsai, C.-C., & Tseng, J. C. R. (2010). A two-tier test approach to developing location-aware mobile learning systems for natural science courses. *Computers & Education*, 55(4), 1618–1627.
- De Jong, T., Specht, M., & Koper, R. (2008). Contextualised media for learning. *Journal of Educational Technology & Society*, 11(2), 41–53.

- De Vries, F., Ternier, S., & Visser, I. (2010). *Audio augmented spaces for learning, ARLearn*. (Eindrapport Innovatieregeling Hoger Onderwijs 2010). Heerlen, The Netherlands: Open University of The Netherlands.
- Dick, W., Carey, L., & Carey, J. O. (2009). *The systematic design of instruction*. Upper Saddle River, NJ: Pearson Education.
- Engeström, Y. (1996). *Perspectives on activity theory*. Cambridge: Cambridge University Press.
- Engeström, Y. (1999). Expansive visibilization of work: An activity-theoretical perspective. *Computer Supported Cooperative Work*, 8: 63–93.
- FitzGerald, E., Sharples, M., Jones, R., & Priestnall, G. (2011). Guidelines for the design of location-based audio for mobile learning. *International Journal of Mobile and Blended Learning*, 3(4), 70–85.
- Florian, B., Glahn, C., Drachsler, H., Specht, M., & Fabregat, R. (2011). Activity-based learner-models for learner monitoring and recommendations in Moodle. In C. D. Kloos, D. Gillet, R. M. Crespo Carcía, F. Wild, & M. Wolpers (Eds.), *Towards ubiquitous learning* (pp. 111–124). Heidelberg, Berlin: Springer.
- Glahn, C. (2009). *Contextual support of social engagement and reflection on the Web*. Doctoral dissertation, Open University of The Netherlands. SIKS Dissertation Series, 2009-27.
- Glahn, C., Mitsopoulou, E., Nake, I., & Wendel, T. (2012). Mobler cards. [Computer software]. Zurich: ETH Zurich. Retrieved February 9, 2013 from <https://github.com/ISN-Zurich/ISN-Learning-Cards/>
- Glahn, C., & Specht, M. (2010). Embedding Moodle into ubiquitous computing environments. In M. Montebello (Ed.), *Proceedings of the 9th World Conference on Mobile and Contextual Learning* (pp. 100–107). Valletta, Malta: University of Malta.
- Glahn, C., Specht, M., & Koper, R. (2008). Smart indicators to support the learning interaction cycle. *International Journal of Continuing Engineering Education and Lifelong Learning*, 18(1), 98–117.
- Hardt, D. (Ed.) (2012). The OAuth 2.0 authorization framework (Proposed Standard IETF 6749). Retrieved February 9, 2013, from <http://tools.ietf.org/html/rfc6749>
- Koper, R., Olivier, B., & Anderson, T. (Eds.) (2003). IMS Learning Design information model (IMS Specification, Version 1.0). IMS Global Learning Consortium.
- Lave, J. (1993). The practice of learning. In S. Chaikin & J. Lave (Eds.), *Understanding practice, perspectives on activity and context* (pp. 3–33). Cambridge: Cambridge University Press.
- Lave, J., & Wenger, E. (1991). *Situated learning, legitimate peripheral participation*. Cambridge: Cambridge University Press. Norton, M., & Panar, A. (Eds.) (2003). IMS Simple Sequencing information and behavior model (IMS Specification, Version 1.0). IMS Global Learning Consortium.

- Reigeluth, C. M. (1983). Instructional design: What is it and why is it? In C.M. Reigeluth (Ed.), *Instructional-design theories and models, an overview of their current status* (pp. 3–35). Hillsdale, NJ and London, UK: Lawrence Erlbaum Associates.
- Reigeluth, C. M. (Ed.). (2009). *Instructional design theories and models, building a common knowledge base*. New York and London, UK: Routledge.
- Sharples, M., Taylor, J., & Vavoula, G. (2007). A theory of learning for the mobile age. In R. Andrews & C. Haythornthwaite (Eds.), *The Sage handbook of eLearning research* (pp. 221–247). London: Sage.
- Sharples, M., Arnedillo-Sanchez, I., Milrad, M., & Vavoula, G. (2009). Mobile learning: Small devices, big issues. In N. Balacheff, S. Ludvigsen, T. Jong, A. Lazonder, & S. Barnes (Eds.), *Technology-enhanced learning* (pp. 233–249). Dordrecht: Springer Netherlands.
- Ternier, S., Gonsalves, A., de Vries, F., & Specht, M. (2012). Supporting crisis simulations with the ARLearn toolkit for mobile serious games. In C. Glahn (Ed.), *Mobile learning in security and defense organisations* (pp. 6–8). 15 October 2012, Helsinki, Finland.
- Verpoorten, D., Glahn, C., Kravcik, M., Ternier, S., & Specht, M. (2009). Personalisation of learning in virtual learning environments. In U. Cress, V. Dimitrova, & M. Specht (Eds.), *Learning in the synergy of multiple disciplines* (pp. 52–66). Heidelberg, Berlin: Springer-Verlag.
- Weiser, M. (1991). The computer for the 21st century. *Scientific American*, 265(3), 66–75.
- Wenger, E. (1998). *Communities of practice: learning, meaning, and identity*. Cambridge, New York: Cambridge University Press.
- Zimmermann, A., Specht, M., & Lorenz, A. (2005). Personalisation and context management. *User Modeling and User-Adapted Interaction*, 15(3-4), 275–302.

PART

III

Using Mobile Learning in Education and Training

Orchestrating the Flexible Mobile Learning Classroom

Chee-Kit Looi and Yancy Toh

Abstract

A key trend in technology-enabled learning is to equip every student with a mobile device in the classroom. As a corollary, there is burgeoning research on the design of classroom curricula and learning activities that harness the affordances of mobile technologies. The key success factors in shaping the effective enactment of such curricula include the teacher's ability to orchestrate and facilitate the classroom learning activities. This chapter explores the issues and problems faced by teachers when they conduct mobile learning (mLearning) curricula in the classroom. We illustrate the complexities of "designing for orchestration" by presenting an example of a "mobilised" primary school science curriculum that runs on smartphones. The systemic influences that promote the marriage of technology and pedagogy for flexible learning are also explained.

Introduction

Orchestration

In the research field of technology-enhanced learning (TEL), the concept of "orchestrating learning" has been proposed as a metaphor for good instructional design and lesson enactment in classrooms. From a teacher's perspective, it is important to enact and recognise the multiple constraints that teachers and students face in real classroom settings. Dillenbourg (2012) uses the term "orchestration" to refer to the real-time management and transition of multilayered activities (such as individual work, group work and class-level discussions) and the multiple constraints (such as time and space constraints, curriculum and assessment requirements, and the energy level of the teacher) in

the classroom. Roschelle posits that the word serves as a beacon to draw attention to the many issues that go into the active ingredients in a classroom innovation to focus on issues of robustness, efficiency, adoptability and adaptability (Dillenbourg, 2011; Roschelle & Teasley, 1994).

To design for orchestration is to recognise the challenges teachers face in enacting and managing a range of activities in a TEL classroom. Such activities are learning scenarios incorporating elements of classroom discourse, and artefacts produced via digital and traditional learning tools across different learning contexts. In this chapter, the orchestration framework of “5+3 Aspects” is used as a conceptual tool to understand orchestration (Prieto, Holenko Dlab, Gutiérrez, Abdulwahed, & Balid, 2011). Arising from the extensive review of the TEL literature related to the concept of “orchestrating learning,” the cohesive framework includes aspects most often mentioned by TEL researchers in relation to this concept. The framework can be used as an analytical lens when researching TEL settings (especially authentic, complex classroom settings). The five main aspects of orchestration are:

1. **Designing/planning:** Planning the learning activities that will be enacted and co-ordinated. Traditionally, this pre-lesson design is often referred to as learning design (Koper & Tattersall, 2005) or is related to the areas of instructional planning and design.
2. **Regulation/management:** Managing the processes of learning and teaching in order to maximise outcomes on a variety of fronts (Watts, 2003) when “it all comes together.”
3. **Adaptation/flexibility/intervention:** Changing and adapting the design or plan to both the local context of the classroom and the emergent occurrences during the enactment of learning activities.
4. **Awareness/assessment:** Being aware of what is happening in the classroom and what students are doing and learning, through ongoing monitoring of the situation. This can range from gaining a high-level sense of how students are responding to determining a more fine-grained level of what and how specific students are assimilating the learning materials.
5. **Roles of the teacher and other actors:** Analysing teacher presence, skills, knowledge, attitudes and rapport in interacting with the students to achieve orchestration.

Prieto et al. (2011) list three additional aspects that focus on how to design and support well-orchestrated learning experiences:

1. **Pragmatism/practice:** Making TEL research results available to typical teachers (as opposed to TEL expert), and addressing the constraints of authentic classroom settings (Dillenbourg & Jermann, 2010). These research results, through feedback loops, can also inform the processes of learning design and lesson enactment.
2. **Alignment/synergy:** This entails co-ordinating and aligning the elements to be orchestrated at various social levels, taking into account the tools and scaffoldings used, including teacher and peer actions and contextual issues like classroom culture and gender to produce synergy.

3. Models/theories: Developing underlying robust theories and models to better inform orchestration. Implicit theories and models about teacher beliefs are also encapsulated in this category.

This chapter considers that models and theories reside at the meta-level — that is, how ongoing research on orchestration can help develop theories or models of orchestration. Here the authors also add the additional aspect of institutional support for teacher’s enactment to emphasise organisational support for their classroom orchestration.

Flexible Learning

The concept of “flexible learning” is shrouded in ambiguity, as it is often unclear: from whose perspective learning is considered flexible; the rationale for advancing the concept; and the constructs that make up this notion (Morgan & Bird, 2007). This results in the gulf between espoused and actual practice at the “site of contestation” (Willems, 2005, p. 434). Collis and Moonen (2001) assert that flexible learning is more than the location of participation; rather, it is about how the dimensions of institution, implementation, pedagogy and technology interact with one another to offer more choices to learners in their learning experiences. According to the authors, the ideal scenario is that flexible learning should lead to contribution, not to acquisition. Khan (2007, p. 1) describes flexible learning as:

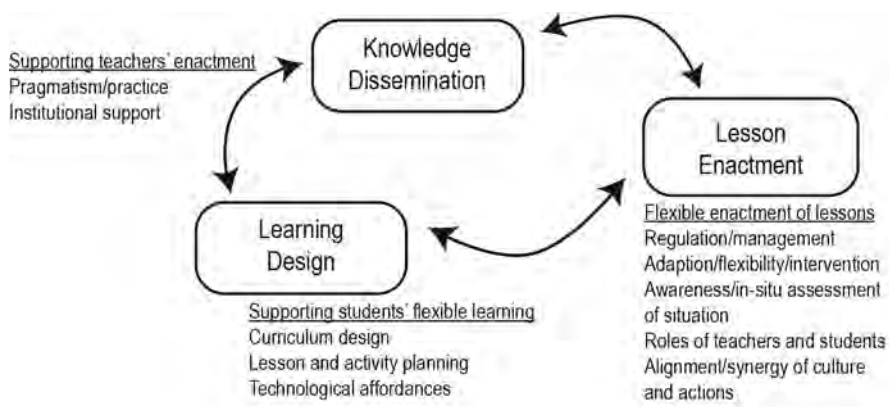
“An innovative approach for delivering well-designed, learner-centred, and interactive learning environments to anyone, anyplace, anytime by utilising the attributes and resources of the Internet, digital technologies, and other modes of learning in concert with instructional design principles.”

In other words, flexible learning makes learning resources and methods increasingly distributed, varied and personalised across temporal and spatial spaces. This has profound implications on both teaching and learning. Willems (2005) underscores the importance of giving learners more control in their learning processes and the choice to decide how they want to be engaged in the learning products and processes.

Putting Them Together

Much has been said about flexible learning, especially in the context of eLearning and higher education. However, situating flexible learning within the nexus of classroom orchestration and mobile learning (mLearning) in primary (elementary) school is rare. It is noteworthy to highlight that both the notions of flexible learning and classroom orchestration share the central tenet of dynamic adaptations based on the needs of students and are therefore considered complementary. The emergent conceptual framework (see Figure 12.1) arose from the literature review and helped us to elucidate our points.

Figure 12.1. Conceptual framework linking classroom orchestration and flexible learning.



The framework proposes that orchestration for flexible learning in a technology-enhanced classroom is an iterative process that involves: learning design, lesson enactment, and knowledge dissemination. In terms of learning design, the teacher considers the overarching curriculum design, lesson and activity planning, and the technological affordances of the tools used. The pre-planned lessons are then subjected to in-situ influences that lead to just-in-time interventions based on the teacher's assessment of the classroom situation. Over time, the actors (students and teachers) need to co-create alignment and synergy between classroom culture, learning resources, and interactive patterns. Insights are then shared and further institutional support given to sustain the orchestration.

The rest of this chapter focuses on: flexible learning to support students' learning, teacher's flexible enactment of the lessons, and knowledge dissemination to further advance flexible learning.

A Case Study of Orchestration: The 1:1 Classroom

There are many classroom contexts for studying orchestration. The authors' interest is in the TEL classroom, specifically one-to-one (1:1) computing in the classroom. In such an mLearning classroom, every student has a mobile device in the form of a TouchPad or smartphone. Before the pervasive use of mobile technologies, there already existed voluminous literature devoted to the discussion of the challenges that teachers face in adopting and integrating the technology. The main question is: Does the use of mobile devices or a mix of technologies (including whiteboards, personal computers) make it easier, or more challenging, for a teacher to orchestrate classroom activities?

The following illustrates a 1:1 intervention in a primary school classroom in Singapore. The example highlights how elements of support are provided for teacher's orchestration.

Design and Planning of the Mobile Learning Curricula

The intervention was co-designed by researchers from the National Institute of Education, Singapore, and one experimental science teacher prior to the

enactment of the lessons in the academic year 2009. In 2012, the experimental classes grew from one class to eight classes (three teachers taught two classes), and participating teachers from levels 1 to 6 across the whole Primary 3 level. Every student was given a Windows-based smartphone with Wi-Fi connectivity.

The objective of the intervention was to harness the affordances of mobile technologies to enhance science learning. It involved the integration of 1:1 smartphones into the science curriculum. We endeavoured to make the redesigned science curriculum adoptable in real classrooms by typical teachers and average-ability students (Looi et al., 2011). Such a transformation of the existing science curriculum necessitated planning for a gradual but fundamental change of the curriculum for it to be sustainable. The process required much time and resources as it covered the multifaceted tasks of co-designing lessons, conducting professional development, setting up technology infrastructure, and evaluating the curriculum enactment.

The lesson design was based on the whole curriculum approach (Zhang et al., 2010). We designed “mobilized” (mLearning) lessons for the entire 21 weeks of the Primary 3 science curriculum. At the heart of the learning design, students needed to acquire science content, grasp inquiry processes and develop self-directed learning competencies. This was achieved by designing learning activities to help students see the connections between scientific concepts and their everyday lives, as well as to enable them to apply their learning in authentic contexts. The following guidelines were used for designing the lessons (Zhang et al., 2010):

- Design student-centred inquiry-based learning activities.
- Exploit the affordances of mobile technologies.
- Assess student learning formatively.
- Facilitate collaborative interactions.
- Make use of community support and resources.
- Support teachers to be good curriculum developers and facilitators.

Many of the activities involved the students’ creation of artefacts using the applications available on the smartphones. The recurrent elements included the use of the smartphone for Internet searches, picture- and video-taking, notes-taking, concept maps and animations production, and as a launchpad for MyDesk applications (see bottom panel in Figure 12.2). The students’ works were uploaded to a server from which the teacher could access, view and comment on their work. The teacher also used these artefacts to elicit students’ understanding and to generate discussion in the classroom. There were various grained-size activities: one learning activity could last a few minutes to a few hours spread over a few days.

Depending on the objectives of the specific science unit or lesson, different websites and applications were then chosen to be used on the smartphones. For example, the teachers and students used the MyDesk platform for their daily lessons (as a learning hub), but were free to use other supporting applications such as Socrative.com, Edmodo, Flash applets and YouTube Channel.

Figures 12.2 and 12.3 show a simple depiction of the lesson design on Body Systems. The goal for this series of lessons was to help students attain the learning objectives for the topic of Body Systems through co-operative and self-directed activities. Classroom hours for learning Body Systems took 4.5 hours in total, spanning three weeks. The designed activities were placed in a lesson package known as MyProjects, which could be accessed by the students on their smartphones as shown in Figure 12.2. A lesson overview shown in Figure 12.3 shows the objectives of the lesson and what is expected from students in learning about the body.

Figure 12.2: Screenshot of a lesson on Body Systems designed for the mobilised learning environment.

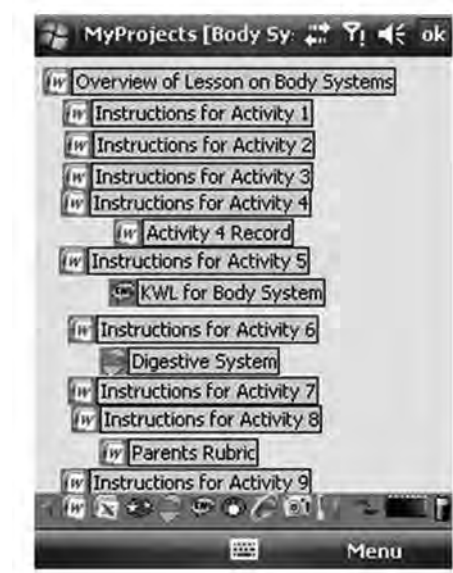
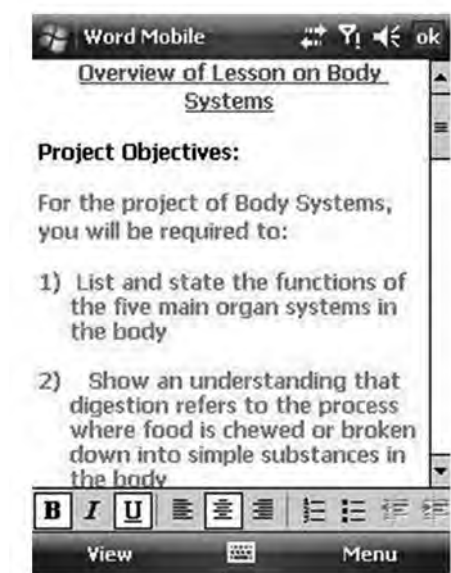


Figure 12.3: Overview of a lesson on Body Systems as displayed on students' smartphones.



The students started the process of inquiry learning by playing a face-to-face co-operative game to identify the parts and functions of body systems. The teacher played the role of a critic to ensure that the students had identified the correct body parts and systems. After the game, the teacher recapped what the students had learnt from one another and reinforced their knowledge on the topic.

Each student was tasked to conduct an experiment on chewing bread at home with the help of their family members. Using the smartphone, the student video-recorded the experiment and discussed the content with their classmates and teacher in class. From this activity, the students were expected to learn that digestion starts from the mouth and aids the digestion process.

Post-experimental activities included students conducting online research on digestive systems with their smartphones, sharing their findings with classmates, updating their KWL (what do I already Know? what do I Want to know? What have I Learned?), and creating animations of digestive processes to illustrate their understanding. This helped the teacher to identify the learning gains and gaps in students' conceptions. The teacher addressed these findings during class time to help students clarify their concepts, and to promote peer evaluation by providing rubrics for students to evaluate

one another's work. The teacher then offered suggestions for improving the illustrations and scientific representations. Thereafter, the students re-submitted their work after taking into consideration the suggestions given by both the teacher and their peers.

Teachers' Enactment of the Lessons

When the science programme was scaled up to the whole Primary 3 level in 2012, all Primary 3 science teachers (the "typical" teacher included) had the opportunity to enact the mLearning curricula based on the same mobilised lesson design (lesson plan). The findings from the classroom observations of six different teachers suggested that they enacted the same lesson design (as expressed in the written lesson plan) differently due to variability in content, pedagogical and technological knowledge, and beliefs about how the students can learn. Some teachers focused on processes such as observation, inference and evaluation, while others focused on the accuracy of concepts acquired by the students. This led to different enactments of the planned lesson.

The degree of student autonomy in directing their own learning was dependent on the degree of control exercised by the teachers. Some teachers built on students' learning needs and interests while others dictated the scope and depth of learning based on their perceptions of the students' learning abilities in class and their command/grasp of the prescribed content in the textbook. Thus, due to the above interpretive flexibility and contextual variability, the experience that each class went through was different, as were the pace, depth and the extent of teacher-centredness.

From the teacher's perspective, the challenges of managing and regulating a redesigned curriculum infused with student-centred philosophy included:

- encompassing and ensuring parental participation in student-directed activities;
- replacing traditional teaching practices, such as completion of worksheets and practice papers; and
- aligning teachers' competency and school goals to the intended design curriculum goals.

As most teachers were used to teaching didactically, one challenge for them was to generate productive talk based on the students' discourse or artefacts.

To illustrate, a typical mobilised lesson starts with a lesson package being "pushed" (downloaded) to the students' phones wirelessly. A teacher might end an activity by providing a discussion or a summary of what the students did (or asking them to summarise or present what they did). The key concept is that it is the teacher who orchestrates the activities, not the technology. Based on the class dynamics and progress, the teacher regulates and decides when to move on or switch to the next activity in class. Certain activities allow the students to work progressively over a span of a few lessons at their own pace. As each student works on his or her smartphone, it is possible for the student to step out of the script/design and do something else. Some latitude can be given to students to complete their own activities as long as there is broad social conformity that these activities serve the purpose of achieving the lesson objectives.

In terms of technology in the case study, MyDesk applications played a central role in providing learning flexibility. The application provides multiple modes of learning such as taking pictures and videos, creating animations, creating mindmaps, using KWL charts (knows, wants to know, learned) and interacting synchronously and asynchronously with teachers and peers. As the teacher might not have the time to view all digital artefacts, he or she would have to orchestrate the activities efficiently and effectively. Some teacher strategies deployed included: getting some groups to present their artefacts to the whole class; and, when students' participation rate in class or online was low, promoting peer learning by showcasing selective artefacts. This was to recognise students' work, encourage them to make constructive feedback and spur them to fine-tune their work.

Adaptation/Flexibility/Intervention

One of the greatest challenges of this intervention was to support teachers in their enactment of the lesson designs. The initial curriculum was designed for a mixed-ability class. Adaptation was required for higher- and lower-ability students and also for teachers with different beliefs and teaching styles. Other factors that shaped the process of curriculum adaptation included the availability of curriculum hours, resources and amount of school-sanctioned workload.

Confounding real-time orchestration efforts was that the lesson plans were written in a form that did not accommodate unanticipated changes, such as network failures, which would prompt the need for teachers to improvise and provide contingency plans on the fly. It was explicitly communicated to the teachers during professional development that in the absence of technology, modifications must be made to deliver the intent of the designed activities. Often, due to the breakdowns in network connectivity, changes were made using non-technological support that bypassed the need for Wi-Fi connectivity. Software failures might also prompt the need to switch plans.

Over time, with the stabilisation of technology and the enhanced ability of teachers to adapt in the event of technology hiccups, they were less dependent on the network because the students were able to continue their work offline. Teachers had also put in place practices to facilitate class discussion and sharing during offline mode. In short, although the technology is embedded in the curriculum, the designed activities could be conducted independently without technology. However, in such cases, the activities tended to be teacher-led and the artefacts produced more homogeneous due to limited alternative platforms for representations of cognitive and social activities.

Awareness/Assessment

A science lesson may include a few learning activities compressed within one or two half-hourly periods. The monitoring of the learning activities could be mediated socially (by the teacher's real-time presence in the classroom) and technologically (by monitoring work uploaded to the server). As an example, on the MyDesk server the teacher can easily view the submission rate of the assignments at a glance and choose to view and grade the students' work. This information is then downloaded onto the students' smartphones to provide individual feedback. Thus, the typical learning cycle that cut across all lessons

was that students created and uploaded their work via technology; and the teacher accessed the students' digital work during or after class and provided feedback during the next lesson.

Work and assessments to be done on the smartphones were designed to make the students' thinking processes visible to the teachers and peers. By creating student-centred activities, teachers did not resort to transmitting knowledge. The choice of tools was open-ended to allow students to construct knowledge and support their inquiry pursuits. Teachers were encouraged not to provide standard answers and to allow a variety of responses. Students' misconceptions were also addressed through just-in-time feedback. In this way, there was an elevated awareness of the students' quality of understanding, thus enabling the teacher to orchestrate what domain concept to focus on when facilitating discussions.

Roles of the Teacher

As "design for orchestration" highlights, the role of the teacher is key in the unfolding of learning activities in the classroom. The teacher had the mobile device which acted as a hub for students to embark on a range of activities. She co-ordinated, monitored and managed the flow of classroom activities. While this sounds teacher-directed, the students also played an important role in dictating how the lessons should unfold in the classroom. The teacher often made decisions based on the quality of participation and artefacts students produced.

In addition, through capacity-building, there was a shift in the ownership of intervention from the researchers to the teachers. Balance of power can be observed as both teachers and researchers contributed invaluable inputs towards the design of curriculum. The pioneering teacher also acted as mentor to other teachers within and beyond the experimental school, thus changing the role of the teacher from an apprentice in the infancy stage to an intellectual partner in the mid-cycle and, later, to a driver of the innovation towards the end of the intervention.

Pragmatism/Practice

Some organisational and school contexts may have worked against the adoption of the revised science curriculum. In the school we worked with, for example, the practice of assessing students via worksheets and practice papers took up much classroom instructional time, leaving less time for the enactment of mLearning lessons. The problem of time constraint was exacerbated when actual curriculum hours were lost due to school activities. To circumvent the problem, the teacher might have used other subject periods to create additional time for the students. In addition, some learning activities had to be scaled back. The challenge was to maintain the number of assessments despite the reduction in the quantity of worksheets.

The learning activities designed considered the curricular goals and the affordances (and constraints) of the technology (the applications and the smartphone functionalities). When the technology on the smartphone did not support the delivery of the intended curricular goals, the researchers would help the teacher to source other complementing technologies. For example, when the online sharing of the students' artefacts via the smartphones was not

available, applications like Edmodo and Picasa were introduced. However, this did not change the curricular designs. When there was a recurrent gap, a long-term solution to develop new applications to fit the curricular designs would be sourced.

Pioneer teachers who had gone through the learning curve then documented and shared their orchestrating experience through the vehicles of in-house professional development sessions or nation-wide professional learning communities.

Alignment/Synergy

Although the science teachers had different prior knowledge and facilitation experiences regarding inquiry learning, they were increasingly aware of the need to change the traditional interaction pattern in classrooms. The use of technological tools by students to perform open inquiries exemplified the need for teachers to focus on sense-making instead of transmitting factual knowledge. In short, technology proffered opportunities to create alignment between lesson activities and the pedagogic objective of advancing inquiry learning when harnessed appropriately. The teacher also facilitated online participatory learning, synthesised different viewpoints and created synergistic learning outcomes.

Institutional Support

Several tensions coalesced around the enactment of flexible mLearning. Many factors can affect the quality of on-the-fly orchestration, including differences in the abilities of teachers to internalise inquiry learning, facilitate techniques, grasp technological skills, use technological tools, and create a learning-conducive classroom culture. Pressure to conform to organisational culture not fundamentally compatible with the implementation of flexible learning can also create problems in educational institutions. Multilevel support was needed to reconcile the tensions. At the organisational level, leaders of the case school had encouraged capacity-building and embedded multiple platforms for sharing informed practices. At the departmental level, heads of department had made changes to the drill-and-practise culture that had been entrenched in the system. Worksheets were reduced and planned activities re-scoped to free teacher time to enact student-centred activities.

Discussion

Successful classroom orchestration for flexible mLearning is not only about the right amalgamation of pedagogical strategies deployed within classrooms. It also depends on the overarching lesson design and dissemination of knowledge embodied in teachers.

Table 12.1 summarises how orchestration amongst the mutually constituting elements of learning design, lesson enactment, and knowledge dissemination can lead to the manifestation of flexible learning.

Table 12.1: Orchestration amongst the mutually constituting elements leading to flexible learning

Processes of orchestration	Elements of orchestration	How flexible learning can be achieved
Learning design	Curriculum design	<ul style="list-style-type: none">Teachers and researchers redesign curriculum to help students acquire skills for science inquiry and self-directed learning skills.
	Lesson, activity planning, and instructional approach	<ul style="list-style-type: none">Lesson design should prevent teachers from relying on just transmitting knowledge.Teachers and researchers design learning activities to help students see the connections between ideas and their everyday lives.Various grained-size activities can be available.
	Technological affordances	<ul style="list-style-type: none">Choice of tools can be open-ended to allow students to construct knowledge and support inquiry (e.g., using smartphones to support data collection anywhere at any time).A suite of learning applications is available to support multimodalities.
Lesson enactment	Regulation and management	<ul style="list-style-type: none">Teachers' competency and school goals can be aligned with the intended design curriculum goals.
	Adaption, flexibility and intervention	<ul style="list-style-type: none">Macro-scripts provided by researchers can enable teachers to enact the same lesson design, with adaptations.Activities can be further customised to cater for differentiated learning across different ability groups.Teachers can make improvisations to lessons when technology fails.
	Awareness and in-situ assessment of situation	<ul style="list-style-type: none">The objective of assessment can be to make students' thinking processes visible.Technology can help teachers track, grade and provide individual comments on students' work, more easily.Teachers should be encouraged not to provide standard answers and to allow a variety of responses.
	Role of teachers and students	<ul style="list-style-type: none">Teachers increasingly become facilitators as students become active learners.Teachers also become drivers of the innovation.
	Alignment and synergy of culture and actions	<ul style="list-style-type: none">Technology can be harnessed to create alignment between lesson activities and the pedagogic objective of advancing inquiry learning.Online participatory learning to create synergistic learning outcomes can be facilitated.
Knowledge dissemination	Pragmatism/practice	<ul style="list-style-type: none">Time constraints can be factored in.Worksheet culture changes.Awareness of innovative learning solutions is promoted.Pioneer teachers mentor other aspiring teachers.
	Institutional support	<ul style="list-style-type: none">Additional time is set aside for professional development and mutual sharing of enactment of lessons.Lesson plans that reflect experiences from completed teacher enactments can be iterated and refined.Management can support move to reduced mandatory worksheets.

Table 12.2 expounds on the elements of learning flexibility from both the perspectives of students and teachers.

Table 12.2: Affordances of flexible learning from the perspectives of learners and teachers

Learning flexibility from students' perspective
<ul style="list-style-type: none">• Time (anytime with “24/7” access of smartphones)• Location (multiple learning spaces: in class, out of class, virtual spaces)• Sources of knowledge (teachers, peers, parents, books, Internet)• Learning pathways (given choice to tackle preferred sub-activities)• Learning approaches (acquisition, application, learning-by-doing, peer learning, individual learning, reflection)• Data collection methods (photo-taking, video-filming, note-taking, tagging)• Knowledge representation tools (audio and video recordings, concept maps, animations, PowerPoint, sharing in social media platforms)
Instructional flexibility from teachers' perspective
<ul style="list-style-type: none">• Curricular organisation (re-sequencing topics, re-scoping activities)• Lesson delivery (flexibility in facilitation techniques and medium, face-to-face or online)• Social organisation of activities (individual or group work)• Formative assessment (more alternative assessment modes to distil misconceptions in addition to tests/worksheets)• Feedback channels (in-class just-in-time feedback, post-activity feedback, online feedback)• Heterogeneous voices/inputs (teacher, students, parents, researchers)

Conclusion

There are different paradigms and approaches for transforming curricula and lessons into one that is delivered primarily via mobile devices. They include mLearning field trips, location-based services, collection of science data from mobile sensors, and other innovative uses. Different approaches can pose different challenges and constraints to teachers orchestrating such activities. Many such curricula are enacted first in the classroom, and we posit that the key challenge is helping teachers to initiate, foster and manage productive discussions that leverage the work that students do on their mobile devices.

Our context for designing for teacher orchestration pertains to an mLearning curriculum that is being enacted by all teachers across a grade level. It involves how to support teachers to enact and customise for their own classes, while at the same time adhering to the pedagogical intent of the original lesson design.

Figure 12.1 represents one view of an emerging framework for linking key aspects of classroom orchestration with flexible learning. This chapter discussed different senses of orchestrating the mLearning classroom flexibly. One is good lesson pre-design which allows appropriation and yet effective enactment by the teacher to support the students to do flexible learning. The other pertains to structures and support for the typical teacher to flexibly orchestrate the classroom well. Together such classroom and organisational perspectives can contribute to the distillation of guiding principles for sustaining flexible learning. Without ongoing systemic support, the efforts to orchestrate flexible mLearning in the classroom may be curtailed due to fundamental ideological differences between the activities and the broader organisational ethos in which these lessons are embedded.

Linking this topic to socio-cultural trends, one possible future research direction could be the study of the impact of flexible learning on nurturing 21st-century learning dispositions. Also, as this study is conducted within the context of a school with 1:1 computing, further investigation should be conducted to find out

how classroom orchestration for mobile flexible learning can be adapted or scaled up in other schools without such provision. The salient principles presented in this chapter could be refined further based on the dynamic pattern-matching of the innovation processes that occurred across schools with varying profiles and initial conditions.

References

- Collis, B., & Moonen, J. (2001). *Flexible learning in a digital world: Experiences and expectations*. London: Routledge.
- Looi, C-K, Zhang, B., Chen, W, Seow, P., Chia, G., Norris, C., & Soloway, E. (2011). 1:1 Mobile inquiry learning experience for primary science students: A study of learning effectiveness. *Journal of Computer Assisted Learning*, 27(3), 269–287.
- Dillenbourg, P. (Ed.) (2011). *Trends in orchestration: Second research and technology scouting report*. Report on orchestration trends of the European Stellar Network of Excellence in TEL. Retrieved from http://telearn.archivesouvertes.fr/docs/00/72/24/75/PDF/20110818_stellar_d1.5_trends-in-orchestration.pdf
- Dillenbourg, P. (2012, March). Design for classroom orchestration. Unpublished position paper. Retrieved from www.cross-field.ch/wp-content/uploads/2013/01/PositionPaperDIII-afterRachelCComments-reduced.pdf
- Dillenbourg, P., & Jermann, P. (2010). Technology for classroom orchestration. In I. M. Khine (Ed.), *The new science of learning: Computers, cognition and collaboration in education*. Berlin: Springer (pp. 525–552). [Trans.: New York, NY: Springer.]
- Khan, B. H. (Ed.). (2007). *Flexible learning in an information society*. Hershey, PA: Information Science Publishing.
- Morgan, C., & Bird, J. (2007). Flexible assessment: some tensions and solutions. In B. H. Khan (Ed.), *Flexible learning in an information society* (pp. 247–259). Hershey, PA: Information Science Publishing.
- Prieto, L. P., Holenko Dlab, M., Gutiérrez, I., Abdulwahed, M., & Balid, W. (2011) Orchestrating technology enhanced learning: A literature review and a conceptual framework. *International Journal of Technology Enhanced Learning*, 3(6), 583–598.
- Roschelle, J. & Teasley, S.D. (1994). The construction of shared knowledge in collaborative problem solving. NATO ASI Series F *Computer and Systems Sciences*, Volume 128, p. 70–97.
- Watts, M. (2003). The orchestration of learning and teaching methods in science education. *Canadian Journal of Science, Mathematics and Technology Education*, 3(4), 451–464.
- Willems, J. (2005). Flexible learning: Implications of “when-ever,” “where-ever” and “what-ever.” *Distance Education*, 26(3), 429–435.

Zhang, B. H., Looi, C. K., Wong, L. H., Seow, P., Chia, G., Chen, W., So, H. J., Norris, C., & Soloway, E. (2010). Deconstructing and reconstructing: Transforming primary science learning via a mobilized curriculum. *Computers and education*, 55(4), 1504–1523.

Mobile Learning in Higher Education

Núria Ferran-Ferrer, Muriel Garreta Domingo, Josep Prieto-Blazquez, Cesar Corcoles, Dr. Teresa Sancho-Vinuesa and Mr. Francesc Santanach

Abstract

There have been ground-breaking experiences about mobile learning (mLearning) throughout the world and some of these are in higher education. Books, conferences, and the Internet have plenty of information related to mLearning. It has become the new buzzword in the education arena. This chapter reviews the literature that covers mLearning in higher education. It places a special emphasis on real experiences, and chronicles the introduction of mLearning at a purely online university. That university is the Open University of Catalonia (Universitat Oberta de Catalunya) based in Barcelona, Spain. It does not offer any face-to-face or blended-learning activities. The approach taken by this university towards mLearning is to consider it as a complement, a part of the teaching and learning processes and students' experience during their courses and throughout their degree. In this sense, the emphasis has been placed on finding out those aspects that are really important in a mobile environment and that bring added value to our students and faculty members. Thus, mobile experiences are not replicas of the PC experience but another layer that enriches the teaching and learning environments for students and faculty.

This chapter presents an overview of successful mLearning experiences in higher education. It discusses best practices and new opportunities at universities. The introduction of mobile applications in teaching and learning experiences, along with the implications arising from this, is presented in a purely online university context. Within this environment, and considering that mobile applications add another layer to the learning and teaching processes, several mLearning applications have been designed to enhance these processes.

Introduction

We live in a new age. This has been called the mobile age or the mobile technical revolution by authors that include Traxler (2009), Frohberg (2006) and Sharples, Taylor, and Valvoulas (2010), and it has been likened to the first and second industrial revolutions. In recent years, the evolution of wireless technologies and development of applications on mobile devices have been spectacular. The appearance of new types of devices is disruptive to education no matter what educators and education institutions do. Therefore, a thorough analysis, from a pedagogical and technological perspective, is key to ensure the adequate usage and implementation of mobile learning (mLearning).

In the past two decades, we have experienced a revolution in wireless communications that has facilitated a reduction in people's dependency on cable in order to communicate. Moreover, we have seen a huge evolution of the performance and features of mobile devices. In many cases and for many tasks this has led to mobile devices being a possible replacement for laptop or desktop computers. While it is hard to say whether the new breed of devices will be a complete replacement, they certainly present a new layer of interaction. Today, we are seeing an explosion of tools and programming languages to develop applications on mobile devices, as well as the creation of new ways to share and download/upload these applications from and to specific markets. This has enabled many programmers to develop mobile applications in a fast, cheap and readily marketable way. It has never been easier to create applications and make them globally available, including in learning environments.

As previously noted, being wireless is one of the main advantages of mobile technology. The fact that access to the communication network is not tied to a fixed location or to the transmission medium has favoured its expansion. Consider this example: In the last five years there are now more mobile telephone users than landline telephone users. The Internet has also benefited from this technology: mobile Internet allows mobile devices and people to connect to the network from anywhere and at any time. As a result, we have seen the emergence of many new services and applications on these devices.

The mobile technology revolution has reached many fields of applications, one of which is mLearning in higher education as discussed in this chapter. It represents a big opportunity to improve learning and teaching in higher education. As Livingston (2009) says, "Mobile phone usage among students is virtually universal, presenting an opportunity for higher education to pursue." Without doubt, we have seen a significant increase of mLearning experience in higher education in the last three years.

The chapter is organised as follows: Section 1 provides a review of the literature and details of successful experiences with mLearning in higher education. Section 2 presents the experience of the Open University of Catalonia (UOC) in mLearning, under the mUOC project, showing how the introduction of the mLearning concept has transformed the way to learn and teach in higher education. Examples are given of the introduction of ad hoc applications and the production of multimedia materials. A brief conclusion completes the chapter.

The Use of Mobile Learning in Higher Education: Brief Literature Review

In the last five years, for many educators, mobile technology in the field of teaching and learning has become one of the most important areas of research. Mobile learning has become a strategic topic for many organisations concerned with education. Ng and Nicholas (2013) describe the information in a number of mLearning publications that were printed from 2000 to 2010. Over 85% of these were published between 2006 and 2010. They also highlight the increase in research activities after 2004. Today, there are many books, articles and experiences about mLearning. But it is rather difficult to find detailed information about mLearning experiences in higher education environments. In this section, various proposals have been found in the literature and reviewed regarding the use of mLearning in higher education. This review is not intended to be exhaustive, since its aim is to identify some good experiences in this context.

Alexander (2004) presents one of the first contributions in this field and identified the technology, learner and learning material, as well as the forms of mobile technology such as mobile devices and access to services. In terms of higher education, he explained that Japanese schools are developing policies to block cheating with the use of SMS (Short Message Service). Some colleges have considered redirecting funding from physical labs to wireless lab equipment. Several campuses, such as Dartmouth University and American University, have rolled out full-campus connectivity clouds. Alexander concludes: “In some ways, we are presently in a state resembling the early 1990s, when we were wiring up campus spaces for the first time and wondering about the new World Wide Web concept.”

Livingston (2009) emphasised that:

- higher education should pursue the global use of mobile phones by students; and
- higher education has not, so far, maximised the delivery of educational experiences and services to students via mobile devices.

According to Livingston, the past decade has witnessed two revolutions in communication technology: the Internet revolution, which has changed some higher education models; and the mobile phone revolution, which has changed nothing. He notes that we are vaguely aware that our students have mobile phones (and annoyed when they forget to turn them off in class), yet it hasn't occurred to us that the fact they have these devices could help our efforts to provide them with educational experiences and services.

Osman and Cronje (2010) present an analysis of the literature about mLearning, to better understand the position of mLearning in higher education. They conducted an online search of the four most important international journals dedicated to research on mLearning:

- *Journal of Educational Technology and Society* (www.ifets.info/others/)
- *International Journal of Interactive Mobile Technologies* (www.onlinejournals.org/index.php/i-jim)
- *International Journal of Mobile learning and Organisation* (www.inderscience.com/browse/index.php?journalCODE=ijmlo)

- *International Journal of Mobile Communications* (www.inderscience.com/browse/index.php?journalID=40)

One of Osman and Cronje's most important conclusions is that "designers and practitioners of education are therefore responsible for producing coherent and reliable accounts of the likely consequences of the proliferation of mobile devices in the higher education landscape." This takes into account the wide variety of ways these devices impact learning, both positively and negatively, and sheds light on the shifts mLearning is bringing to higher education. Gupta and Koo (2010) presented an empirical survey methodology to study various mLearning tools that are currently available in higher education. Those authors also showed the advantages and disadvantages in mLearning scenarios.

More recently, Solvberg and Rismark (2012) noted that students in mLearning environments make choices as to when they want to access the resources for learning purposes, where they learn and how they use the learning materials. The authors presented a study that showed the limitations of how students act within mLearning environments — the students in the study used mobile devices to access video-streamed lectures; and recommended that future studies of mLearning environments look into the use of other types of learning material. For example, short videos and quizzes could bring additional learning spaces into focus. Furthermore, to improve the teaching and learning quality, say Solvberg and Rismark, it would be interesting to identify and analyse student's profiles through their habits, beliefs and attitudes towards the use of mobile devices.

From this short review of the literature, we can detect that the authors agree about the importance of mLearning in higher education. But it is also evident that there is a lack of real applications being developed; and the majority of these applications are being experienced only by a small number of students. Additionally, we believe the key to an explosion of mLearning in universities is by creating powerful educational applications. These applications must be mobile, multimedia and multi-device. From here, it will open up a path to share and enhance applications that will certainly take us to another educational landscape. We next present some examples of real applications in higher education.

Experiences with Mobile Learning in Higher Education

uMobile (www.jasig.org/umobile) is an open-source initiative created in 2007, through the participation of Cornell, the Sorbonne, Yale and other universities. It brings campus applications, content and data to mobile devices, both in the form of apps (smartphone applications) for the more common operating systems and browser-based content for the rest. Initial modules include campus maps, directories, announcements, search, courses, campus news and calendars (Figure 13.1).

Figure 13.1: uMobile example.



Blackboard Mobile Learning

Major software enterprises are now creating applications for mobiles for use in higher education. It is easy to believe that this type of initiative will be widely used in higher education in the future, in the same way that other apps are used for mobile devices.

Kinash, Brand and Mathew (2011) studied the use of Blackboard Mobile Learn at Bond University in Australia. Blackboard Mobile Learn is an app that works on mobile devices such as the iPad, iPod and the iPhone and other smartphones (Figure 13.2). Once activated by the university, Blackboard Mobile Learn enables students to use their existing Blackboard username and password to access their subject sites, post to discussion forums, submit assignments and participate in all other activated information and communication tools by using their mobile devices.

The authors share the results of research that followed 135 students engaged in mLearning over two semesters: the final semester of 2010 and the first semester of 2011. The largest proportion of students responding (51%) neither agreed nor disagreed that the iPad improved their learning. Of those who indicated a position off the midpoint, there was a slightly higher frequency towards agreement, with 26% indicating agreement and 1% strong agreement, compared with 20% indicating disagreement and 1% strong disagreement. The final percent selected “not applicable.” The distribution of responses to the statement “The iPad motivated me to learn” was skewed in that the frequency rose from strongly disagree to the highest response category, agree. The highest frequency of respondents (42%) indicated agreement, 32% neither agreed nor disagreed, 18% disagreed, 3% strongly disagreed and 5% strongly agreed. No one indicated “not applicable.”

Brand et al. concluded that “Educators are to be encouraged to use mobile learning in their suite of approaches to quality teaching and learning in higher education.”

Figure 13.2: The Blackboard Mobile Learn platform.



Ryerson University

Wilson and McCarthy (2010) reviewed experiences at Ryerson University Library (Toronto, Canada) of creating mobile applications for the university’s campus (Figure 13.3). The authors show how library services can be adapted to the mobile environment and how the library can play a role in broader campus mobile initiatives. To remain relevant, it is important that libraries adapt their services to this new environment.

Figure 13.3: The Blackboard Mobile Learn platform.



Open University Malaysia

Lim, Fadzill, and Mansor (2011) describe the Open University Malaysia’s efforts in enhancing the blended learning approach for undergraduate distance learners with the successful implementation of the mLearning via the SMS initiative

(Figure 13.4). The pilot project was implemented in the May 2009 semester, and the January 2011 semester will be its sixth consecutive semester. This SMS initiative enables the university to reach out to learners outside conventional communication spaces, and it helps keep learners connected to the university, their peers and their tutors.

Figure 13.4: Short Message Service (SMS) initiative at the Open University of Malaysia.



Seven Higher Education Institutions Most Creatively Using Mobile Technology

A review of a number of creative current uses of mobile technology at a wide variety of higher education institutions, public and private, was done by Marquis and Rivas (2012), taking into account experiences from around the world.

- Abilene Christian University in the U.S. has led numerous efforts to incorporate mobile devices into classroom settings, including efforts by chemistry professors — Dr. Cynthia Powell and Dr. Autumn Sutherlin — to podcast and comprehensively research student engagement with technology. Powell is also the founder of Mobile Enhanced Inquiry-Based Learning (www.meibl.org/), a blended learning strategy addressing the problems of inquiry-based learning and focusing on mobile usage in the STEM fields (in the categories of science, technology, engineering, and mathematics).
- Canada’s University of Ottawa’s bilingual app, uoMobile, provides comprehensive mobile access to the most popular sections of its main website, plus services such as access to personal schedules or grades.
- Bangladesh Open University is a distance learning institution that uses methods such as blending SMS with TV and radio for a multimedia experience to improve student engagement.
- Northeast Community College’s journalism school in the U.S. uses wireless technologies to put learners in face-to-face contact with practitioners in order to discuss the current professional environment and its adaptation to the digital age.

- Purdue University has created Hotseat (see Figure 13.5), “a social networking-powered mobile Web application, which creates a collaborative classroom, allowing students to provide near real-time feedback during class and enabling professors to adjust the course content and improve the learning experience. Students can post messages to Hotseat using their Facebook or Twitter accounts, sending text messages, or logging in to the Hotseat Web site.”

Figure 13.5: Purdue University’s Hotseat Web application.



- The University of Michigan’s Mobile Apps Center provides a Mobile Developer Toolkit intended to encourage students, faculty and staff to develop and distribute useful mobile applications to the university community (Figure 13.6).

Figure 13.6: University of Michigan’s Mobile Developer Toolkit website.



- Seton Hall University in the U.S. was the first higher learning institution, in 2010, to assign an iPad to every full-time student and faculty member. The devices provide apps, such as the Reeves Memorial iLibrary, allowing mobile access to its library catalogue.

mUOC: Mobility, Multimedia and Multi-Device

The Open University of Catalonia (UOC), based in Barcelona, Spain, is an online university established in 1994 as a distance university in the Catalan education

system. In the 2012/2013 academic year, 62,000 eLearning students were enrolled in 15 undergraduate courses and 16 masters programs. Since its foundation, the UOC has been using information and communication technology (ICT) as the basis for students and lecturers to interact throughout the learning process. Its aim is to help people reach their learning needs and provide complete access to knowledge beyond the constraints of space and time. Therefore, students and docents can conduct their activities without having to be in the same place at a specific time.

The main features of students enrolled in undergraduate courses are that most of them have previous university studies or a degree; their average age is between 26 and 35 (53.8%) — mature students (Sutherland, 1999); more than 85% of them have a full-time job; and 55% have family responsibilities.

UOC faculty consists mostly of academics (last term 2,865) who are, at the same time, full-time employees at other universities or teachers at high schools, or are (in the minority) business professionals. Since the beginning, UOC has developed a catalytic role in the acquisition of teaching and learning digital skills and their application in other institutions and educational sectors. This model, promoted by the Catalan government, has been an effective formula to promote skills acquisition and the use of digital technology within the Catalan educational space.

In the mid-1990s, when the university was born, UOC's students were required to have access to a PC with Internet connection to be able to follow their studies. That was a handicap for Spanish citizens because only 0.2 million of the 39 million population had access to the Internet from their household. This burden was overcome easily and faster than expected so eLearning could provide 24-hour access to educational resources, without requirements of physical presence on campus.

After the blossoming of smartphones and tablets, mobile technologies have led UOC to enhance the quality of this model and its impact on society. Tablets and phones bring new possibilities that enable new educational contexts not possible with computers. Mobile learning extends the eLearning concept by facilitating access to resources from any location, with strong searching capabilities (i.e., GPS positioning) and rich user interactions. The devices enable students and teachers to work when commuting or on a trip, to check email during wait times, and to extend traditional teaching and study times and locations. And each device, by its nature, leverages certain activities: “I want to check” (phone), “I want to immerse” (tablet), “I want to manage” (computer). Hess (2012) differentiates between physical context (location) and intentional context (intention of use). He considers himself a “location agnostic,” instead associating devices with purpose. This shift away from objective context towards subjective context will reshape the way experiences are designed in future across and between devices, to better support user goals and ultimately mimic analog tools woven into our physical spaces.

In summary, the combined and complementary use of these three devices now provides more possibilities for best performance in the learning process. Therefore, mLearning cannot be seen as a replica of computer-based learning, but must be seen as a complement, a new layer, that increases the opportunities for learning and teaching.

The mLearning strategy at UOC has been developed through the institutional mUOC project. mUOC seeks to facilitate and spread the use of mobile devices as an innovative and effective element for the learning and teaching process and as a complementary element to the common PC. In the January 2013 semester, 94% of students owned a laptop, 76% a tablet and 45% an e-reader, although more than 90% still used PDFs and 80% of students still preferred the use of paper despite MobiPocket, e-publications, audiobooks and other formats that have been available by the virtual classrooms to download since 2009.

Thus, behind the mUOC project lies the idea of reshaping the process of designing learning activities and creating the most appropriate learning resources. At the moment, the majority of study materials are paper based and distributed physically. If mUOC is successful, it is likely that students in the future will find other supports to be the most suitable channels for learning. For this aim, one of the main objectives of mUOC is to explain to students and faculty how they can use these devices for their academic duties. For this, a social virtual platform has been created so students can share experiences when studying and to support learning among and between students and faculty. Another purpose of the project is to broaden the generation of multimedia content, as it is viewed as a suitable format for mobile devices. For this reason, a Multimedia Laboratory was created (December 2012) to enable faculty members to easily produce and edit videos. They have the support of the Learning and Audiovisual Support Services and the virtual space developed and maintained for training via video tutorials in order to ensure that lecturers can acquire the required multimedia competences by developing multimedia projects autonomously.

Complementing the mUOC project, there is the OpenApps platform that collects and makes accessible all the best teaching practices, teaching experiences know-how, and technical solutions at the university. For example, LiveScribe (www.livescribe.com) video is used to demonstrate best practices on maths, and there are other cases showing how to create videos on topics such as how to develop oral competencies or how to learn a foreign language. Lastly, it is a key issue in the eLearning processes that, where intensive use is made of mobility, multimedia and multi-device, all learning resources be tied into the learning plan. It has to be centred on the student activity, and the teacher's role is as learning facilitator rather than as content dispenser.

mUOC: 11 Significant Examples

In this section, we identify applications and usage patterns of mobile technologies that facilitate and enrich teaching tasks. As previously explained, UOC has set up a Web space where academics can share their experiences and practices on how to use such mobile technologies. In particular, we focus on multimedia content mobile capabilities. Such devices let us take pictures and record and play video that can be edited and modified by using apps. As a result, teachers have the opportunity to interact with students through 21st-century formats and publish content through multiple channels such as YouTube, iTunesU, Open Courseware and others. For instance, UOC has an app that allows the creation of educational videos from a tablet — similar to the video tutorials available in the Khan Academy's collection (www.khanacademy.org/).

The UOC's approach to mLearning, mUOC, has been to provide, through mobile devices, the functionality and applications that best suit a small screen and a mobile context. That is why the mUOC project also embraces the development of several apps, developed on an ad hoc basis, for supporting learning and teaching. The following experiences have all been designed to fulfil specific user needs under the mUOC concept (mobility, multi-device and multimedia). By following a user-centred design process, we make sure that we know the way our students learn as well as their expectations, needs and limitations. This helps us to choose and design solutions that can really enhance their learning experiences.

It is important to remark that UOC-made apps are not the only relevant way to address the problem. In fact, in the apps market there are plenty of third-party apps that students and faculty may use to improve their learning and teaching experience. These include: readers giving access to learning materials and note-sharing; apps for note-taking and writing with a stylus pen; apps for video editing and creation; serious games related to specific subjects; simulators; management apps; services such as Dropbox (www.dropbox.com) and Evernote (www.evernote.com); and calculators, dictionaries and the like.

Each student or faculty member has his or her own specific needs, devices and contexts of use. This means that the set of suitable apps should be easy to find and select. This is the reason the mLearning social website (<http://mlearning.uoc.edu>) mentioned above was created. This website is a virtual space where students and faculty can share their preferences, experiences and recommendations. The aim is to provide a learning app market categorised and filtered by device, context, and learning and teaching actions. Through the website, users are able to set up for each device the best apps for performing their learning and teaching activities.

In short, mLearning at the UOC is a work in progress based on user research that allows us to find, design and develop applications that our students and faculty need, and to put them in practice in real environments. Through the evaluation of these experiences, we keep improving and enhancing mobile experiences that take into account the mobile, multimedia and multi-device approach. Besides these mLearning applications, specific to teaching and learning, the UOC has also undertaken several projects to facilitate the mobile experience. Some of these projects are: mobile campus, contents4iPad and mobile UOC apps for webmail.

1. *Multiformat of learning materials*

In 2004, we ran a user study to find out how our students worked with the learning materials. From this study, we found that students take different approaches depending on the learning goal they are pursuing, and from this we initiated a project called Multiformat, aimed at designing and providing students with a variety of formats for the learning materials. Text, audio and video formats are created from a unique XML file, so students can listen to the materials in audio format while they commute, visually impaired students can use their DAISY device, and students looking for the meaning of a specific word from their computer can open the PDF file to look for it. Multiformat adapts to the users' needs, goals and devices, allowing for an enhanced learning experience in different environments (Figure 13.7).

Figure 13.7: Multiformat materials, Open University of Catalonia.



2. Classroom Alerts app

The majority of UOC’s students work full-time, most have family responsibilities, and many face time-consuming commutes — all factors that add stress to the studying situation. Therefore, being able to check what is going on through classroom alerts allows students to keep up-to-date wherever and whenever they want (Figure 13.8). An internal research study, based on contextual inquiry technique, involved seven students during their commuting. Data from this study showed that just checking the alerts reduced the stress they felt related to study load.

Figure13.8: Classroom Alerts app, Open University of Catalonia.

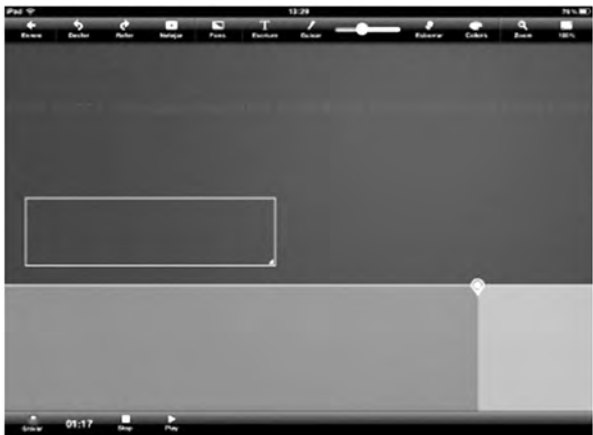


3. Guixa

A project on how to provide e-feedback — that is, how to use audio and video feedback to enhance the learning experience and students’ grades — led us to start another project called Video Skills. The idea was to facilitate the explanation of difficult concepts via video, giving teachers an easy way to create, record and publish videos to accompany explanations in their classrooms. By taking these elements into account, we benchmarked existing apps and opted to develop a new one that we call Guixa, which means “draw” in

Catalan. This app allows teachers to draw on a digital blackboard at the same time that their voice is recorded (Figure 13.9).

Figure13.9: Guixa app, Open University of Catalonia.



4. *iPAC*

To enhance the learning experience of our students, we also work intensively to improve teaching tools. By reducing the time used for mechanical tasks and providing better classroom tools, we increase the time that teachers spend providing real teaching to students. Towards this goal we have developed an iPhone app that downloads and uploads all the students’ assignments to the device and allows PDF files to be annotated in a way that is similar to reviewing on paper. From our user studies, we know that teachers still prefer to print and correct on paper. However, this prevents students from seeing their assignments with the annotations. Using the iPAC app, teachers do not need to make corrections on a computer screen and students can get feedback (Figure 13.10).

Figure 13.10: The iPAC app, Open University of Catalonia.



5. Polls and quizzes

Besides browsing and reading their learning materials in mobile contexts (e.g., during commutes), students appreciate the possibility of getting instant feedback on the knowledge they have acquired. We have worked on a small application based on Moodle and microblogging to allow for teachers to create Yes/No questions that students receive on their mobile devices (Figure 13.11).

Figure 13.11: Polls app, Open University of Catalonia.



6. Microblogging

A key feature of the UOC is to provide new and additional teaching and learning tools that respond to the needs of specific teaching settings. In this way, the classroom design offers teachers a set of tools to add to the students' learning process. One of these tools is microblogging. It is used for various purposes, such as to share links and information, reduce the feeling of loneliness, and improve classroom environment dynamics. In this sense, being able to access the microblogging tool via a mobile device is very important. It is similar to the Classroom Alerts app, but the interactivity lets students access their classrooms' microblog from mobile devices.

7. Mobile Campus

This is a version of the virtual campus for mobile browsers. It adapts the functionalities and information from the virtual campus to the requirements of browsers on smartphones and digital tablets. It is specifically designed for easy and intuitive navigation.

8. Contents4iPad

This project adapts pedagogical materials to exploit the potential of touch-screen tablets in the educational sphere. In essence, it is an electronic publication showing different ways to present information that makes up a particular didactic material.

9. Mobile UOC apps

This set of native UOC applications for mobile devices, on the major platforms (iOS and Android), provides access to information and

content from the virtual campus. iUOC for iPad is an application for accessing the virtual campus and educational materials, while the UOCmail app for Android and iPhone provides all the email client benefits from a mobile device with its operating system. The application and updates are available from the Android market.

10. *Augmented Reality*

This is an educational application that enhances the vision of the real world through mobile devices. It allows one to construct, through augmented reality tools, landscape units that have cultural or heritage interest. Today in Catalonia there are more than 150 points of interest that have valuations as augmented reality, which is valuable to visitors.

11. *Mobile Accessibility Lab*

This multi-device accessibility laboratory enables a person to evaluate the accessibility and usability of websites and mobile applications. It also allows accessibility and usability testing in context, and is especially useful for individuals who are visually impaired.

Conclusion

This chapter has presented an overview of mLearning experiences in higher education, with the aim of sharing experiences and highlighting new opportunities for universities. Most initiatives started only two years ago. Mobile learning in higher education has just begun.

The experiences of the UOC (a fully online university) have been presented in detail. Since 2011, the UOC has defined its strategy of fostering the mUOC concept for its teaching and learning activities. This means promoting mobility, multi-device and multimedia teaching and learning approaches.

Mobile learning is introduced as complementary to computer desktop activities. It doesn't make sense to go mobile for all learning and administration processes, as users have multiple devices. It is not the physical context (location) that matters but the intentional context (intention of use). The combined and complementary use of PC, tablets and mobile phones now provides more possibilities for best performance in the learning process.

Mobile learning, and therefore the mUOC project, brings mobility and multimedia into the learning arena. Furthermore, the quality of learning practices is increasing. Mobile apps and multimedia content are resources that help avoid teacher-centred education (teaching through a mediated, authoritative textbook or with course content that learners digest). Teachers and learners can become creative and collaborative with their own content (OLCOS, 2007).

This type of practice needs the management team at educational institutions to place greater value on teaching and not to define academic careers that are based only on the number of scientific papers an instructor has in indexed journals. To properly prepare the professionals of the 21st century, it is necessary to move towards excellence in both teaching and high-quality research.

Educational institutions that want to introduce mLearning must also implement appropriate training and support. This is imperative to ensure that management staff and faculty acquire the necessary competences so that broader and sustained participation by staff can be achieved.

References

- Alexander, B. (2004). Going nomadic: Mobile learning in higher education. *Educause Review*, 39(5), 28–35.
- Frohberg, D. (2006). Mobile learning is coming of age: What we have and what we still miss. DeLFI 2006 Conference. Presented at the e-Learning Fachtagung Informatik, Darmstadt, Germany.
- Frohberg, D., Göth, C., & Schwabe, G. (2009). Mobile learning projects—a critical analysis of the state of the art. *Journal of Computer Assisted Learning*, 25(4), 307–331.
- Gupta, B. & Koo, Y. (2010). Applications of mobile learning in higher education: An empirical study. *Journal of Information and Communication Technology Education*, 6(3), 75–87. doi: 10.4018/jicte.2010070107
- Herrington, J., Herrington, A., & Olney, I. (2012). Mobile learning in higher education: Authentic tasks, assessment and Web 2.0. In T. Amiel & B. Wilson (Eds.), *Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications 2012* (pp. 1988–1993). Chesapeake, VA: AACE.
- Hess, W. (2012, February 17). Location agnostic, context specific. Message posted to: <http://whitneyhess.com/blog/2012/02/07/location-agnostic-context-specific/>
- Hung, J. L., & Zhang, K. (2011). Examining mobile learning trends 2003–2008: A categorical meta-trend analysis using text mining techniques. *Journal of Computing in Higher education*, 24(1), 1–17.
- Kinash, S., Brand, J. & Mathew, T. (2012). Challenging mobile learning discourse through research: Student perceptions of Blackboard Mobile Learn and iPads. *Australasian Journal of Educational Technology*, 28(4), 639–655.
- Lim, T., Fadzil, M., & Mansor, N. (2011). Mobile learning via SMS at Open University Malaysia: Equitable, effective, and sustainable. *The International Review of Research in Open and Distance Learning*, 12(2), 121–137.
- Livingston, A. (2009). The revolution no one noticed: Mobile phones and multimobile services in higher education. *Educause Quarterly*, 32(1).
- Marquis, J. W., & Rivas, K. (2012, May 28). Ten colleges most creatively using mobile technology. Message posted to: <http://apprenticeshipblog.wordpress.com/2012/06/03/10-colleges-most-creatively-using-mobile-technology-online-universities/>
- Ng, W., & Nicholas, H. (2013). A framework for sustainable mobile learning in schools. *British Journal of Educational Technology*, 44(5), 695–715.

- Open eLearning Content Observatory Services (OLCOS) (2007). *OLCOS roadmap 2012*. G. Geser (Ed.), Salzburg Research, EduMedia Group, Salzburg.
- Osman, M.H., & Cronje, J. C. (2010). Defining mobile learning in the higher education landscape. *Educational Technology & Society*, 13(3), 101–110.
- Sharples, M., Taylor, J. & Vavoula, G. (2010). A theory of learning for the mobile age. In B. Bachmair (Ed.), *Medienbildung in neuen Kulturräumen*. Stuttgart, Kohlhammer Verlag, pp. 87–99.
- Solvberg, A. A., & Rismark, M. (2012). Learning spaces in mobile learning environments. *Active Learning in Higher Education*, 13(1), 23–33.
- Sutherland, P. (1999). *Adult learning: A reader*. London: Routledge. ISBN 0749427957.
- Traxler, J. (2009). Learning in a mobile age. *International Journal of Mobile and Blended Learning*, 1(1), 1–12. doi: 10.4018/jmbl.2009010101
- Wilson, S., & McCarthy, G. (2010). The mobile university: From the library to the campus. *Reference Services Review*, 38(2), 214–232.

Mobile Learning in the Workplace: Unlocking the Value of Mobile Technology for Work-Based Education

Christoph Pimmer and Norbert Pachler

Abstract

The use of mobile phones is attracting considerable interest in the fields of professional learning and work-based education. Surprisingly, there is relatively little systematic knowledge about how mobile devices can be used effectively for learning and competence development in work contexts. Many of the current approaches tend to repackage eLearning content in order to make it suitable for the smaller screens of mobile devices — following behavioural and cognitive paradigms. By contrast, we attempt to illustrate in this chapter how mobile devices allow the realisation of rich pedagogical strategies. We use a number of educational parameters to characterise mobile learning (mLearning) as learning across different contexts that bridges and connects: 1) the creation and sharing of content; 2) learning *for* and learning *at* work; 3) individual and social forms of learning; 4) education across formal and informal settings, and (5) situated, socio-cognitive, cultural, multimodal and constructivist educational paradigms. We underpin our arguments with empirical studies from different fields and disciplines of work-based education. In so doing, we conclude that, in addition to sporadic, self-contained training, mobile devices can connect and span different situations and forms of learning and, accordingly, support learners across various contexts and phases of their career trajectories.

Introduction

Mobile learning (mLearning) appears to be an ever-growing educational phenomenon. In the field of work-based education and workplace learning, mobile technologies such as cellphones, smartphones and tablets are generating considerable interest. However, there is surprisingly little systematic knowledge available about how mobile devices can be used effectively for learning and

competence development in the workplace — except for first empirical studies (see, for example, Pachler, Pimmer, & Seipold, 2011a, 2011b) and theoretical and conceptual discussions (Pimmer, Pachler, & Attwell, 2010). Before we elaborate our arguments, we will briefly problematise the notion of work-based mLearning, a rather immature and emerging field of practice and research. In so doing, we combine and draw on approaches from work-based learning and mLearning. Accordingly (and drawing on Pachler, Bachmair, & Cook, 2010; Pachler et al., 2011a), we understand “work-based mobile learning” as:

“the processes of coming to know, and of being able to operate successfully in, and across, new and ever changing contexts, including learning for, at and through work, by means of mobile devices.”

This rather broad scope refers to the dynamic nature of work-based education and includes education in informal learning contexts. Similarly, it bridges workplace learning perspectives and those that frame work-based learning as a series of formal educational programmes (Evans, Guile, & Harris, 2010).

Like every technological innovation, mobile devices have the potential to innovate and enrich existing educational practices. However, considering the use of technology to date, the opposite appears to be true. It has been argued that new technology has been primarily used to reinforce traditional, instructional and teacher-centred pedagogical approaches (Attwell, Cook, & Ravenscroft, 2009; Hug, 2009) — or in the words of media theorist Marshall McLuhan, “We look at the present through a rear-view mirror. We march backwards into the future” (Woodill, 2012, quoting McLuhan). In work-based education this seems to be true for technology-enhanced learning (Kraiger, 2008) and also for mLearning.

For example, results from one of the first studies in the field indicate that many experts expect the provision of content on mobiles for individual study to be the prevailing form of corporate mLearning in the near future (Pimmer & Gröbhel, 2008). Indeed, many of today’s mLearning “solutions” tend to offer traditional eLearning content on mobile devices, as exemplified by the following case study presented by Swanson (2008).

Traditional approaches to mobile learning: a case from the finance sector

A big company from the finance sector piloted mLearning for its highly mobile investment bankers. They provided compliance training material from the corporate learning management system (LMS) to the bankers’ BlackBerry devices, mainly in a push mode. In order to make content suitable for mobiles, learning objects were downsized, for example by replacing multimedia-rich content with images and text. Learning was centred on individual, self-directed study. The compliance training intended primarily to prepare learners for potential future use. Industrial standards such as the Sharable Content Object Reference Model (SCORM) were used to guide and structure the technological and educational design in a rather formal way.

The pilot was considered a success: it was well received by managers and staff, who mostly studied “on the road,” such as during business travel. Effectiveness was measured by a summative assessment. According to Swanson (2008), a 1.21% increase in average competency score for this group compared with the control groups was reported.

Table 14.1 summarises the main characteristics of what we consider to be a traditional approach to (mobile) learning in work contexts.

Table 14.1: Traditional approaches to technology-enhanced and mobile learning in work contexts

Contextual parameters	Traditional approaches	Excerpts from an mLearning case study (Swanson, 2008)
Content	Delivery	Standardised: “compliance training courses via BlackBerry” Reductionist: “Replace video and audio segments with photos or photo series and transcripts.” Push: “courses were pushed out”
Proximity to work processes	Learning for work	Context-independent: “to deliver learning anytime and anywhere”: 32% completed the learning during business travel, 24% while commuting to work, 26% at home, and 18% in the office or elsewhere
Social form	Individual	Human–computer interaction: “Allow the learner to ... communicate back and forth with the internal LMS.”
Degree of formality	Formal	Highly structured: “Standards, such as SCORM, helped guide the methodology for the technology design.” ... “tools for reporting, troubleshooting, course and learner-level permission structures”
Educational paradigm	Cognitive, behavioural	Outcome/summative assessment: “1.21 per cent increase in average competency score” Duration: “a more timely completion of compliance training, including a 12 per cent higher completion rate”

Learning Across Contexts

We do not want to criticise learning in the form described in the previous section. However, we do suggest that many opportunities would be missed if mLearning remained limited to the approach outlined above. We argue that the particular value of work-based mLearning lies in connecting learning across different contexts, thereby bridging typical dichotomies of educational science. Below, we describe a number of educational parameters — such as content, process, social form, degree of formality and educational paradigm — to show how different contextual dimensions can be linked by means of mobile devices.

Bridging Creation and Sharing of Content

Shrinking eLearning content to make it accessible on mobile devices might be the most intuitive approach to mLearning. Such efforts can certainly have their merits, in particular to reach distant and mobile employees, such as the investment bankers described above (Swanson, 2008), on-the-road engineers (Weekes, 2008) and professional drivers (de Witt, Ganguin, & Mengel, 2011; Stead & Good, 2011). We agree, however, with Woodill (2012), who argues that the “full potential of mobile communications for learning will not be realized until we stop producing learning apps or mobile websites that simply repackage classroom materials to be read or played with on a smaller screen.” Instead, we suggest that, from a pedagogical perspective, the learner-centred creation and sharing of content such as multimedia materials in the form of text, audio, images and video is much more promising.

There are several examples in the literature showing how learners from different backgrounds adopt mobile technology to create and share their own learning content. For example, Brandt, Hillgren, and Björgvinsson (2005) demonstrate how nursing staff at an intensive care unit videotape the handling of technical equipment. The learning sequences produced were then accessed by colleagues through their hand-held computers. Similarly, Wallace (2011) shows how park rangers use mobile technology to produce digital stories of regular tasks and share them with their peers. These context-specific, multimodal and multilingual teaching materials are used as refreshers or as instructions for new members. Importantly, these two examples show that both production — in the sense of active knowledge construction — and sharing of the videos provided valuable opportunities for peer-to-peer learning and reflective practice.

Drawing on, and compiling, a multiplicity of different modes in the form of a story represents a multimodal design for learning. It also offers specific affordances for meaning-making and identity development (Bezemer, Jewitt, Diamantopoulou, Kress, & Mavers, 2012) — for example, allowing learners to demonstrate specific competences in their process of becoming full members in a community of practice (Brandt et al., 2005; Wallace, 2011). Generation and sharing of multimedia involves key functionalities of mobile devices. While multimedia capture is nothing new, the integration of various functionalities in one (mobile) device — referred to as convergence in the literature (Pachler, Bachmair, & Cook, 2010) — provides new and simple opportunities for learning.

Bridging Learning *for* with Learning *at* Work

Standard school systems as well as many forms of corporate training are based on the concept of “just-in-case” learning: declarative and often abstract and generic knowledge is acquired “off-the-job” to qualify learners for work. An example is the above-mentioned compliance training from investment banking that prepared learners for future application. By contrast, just-in-time learning normally takes place *at* work and is immediately relevant for learners (Harris, Willis, Simons, & Collins, 2001). Mobile devices can provide opportunities to connect both learning *for* and *at* work in that they support learners in situ when those learners apply abstract knowledge in order to tackle immediate work challenges. An example is accessing codified knowledge from Internet or intranet searches.

Findings from a recent study at IBM illustrate this view. Similar to the investment banking case outlined above, IBM initially considered delivering its 25,000 employee-development mini-courses “anytime and anywhere” on smartphones. However, they found that employees in nearly all businesses were not using their phones for studying online courseware. Instead, they accessed resources for “in-field performance support.” These findings have led to a change in IBM’s mLearning strategy: it started to prepare a system to better support employees in the solving of immediate work challenges by, for example, accessing checklists with critical information prior to client meetings from internal company networks (Ahmad & Orion, 2010). This is very much in line with the “pull principle” envisaged by Hagel, Brown, and Davison (2009). They stress the role of technology in helping people to access resources, not anytime or anywhere but exactly when needed.

While mobile phone based decision-making and problem-solving support can certainly increase productivity, its educational value needs to be examined more closely. Studies from the field of clinical workplace learning support the view that information provided directly at the point of care can augment self-directed learning practices. Examined, for example, is how medical students in clinical workplaces use mobile devices to support learning and sense-making that arises within the immediacy of a situation, linking codified knowledge from Internet sources with situated experiences (Pimmer, Linxen, Gröhbiel, Jha, & Burg, 2012). In another study, the impact of mobile clinical decision support systems was tied to learning and practice improvement (Grad, Pluye, Meng, Segal, & Tamblyn, 2005). Further studies from clinical workplaces demonstrate that the use of mobile phone or PDA-based decision support tools can decrease learners' uncertainty and increase their self-confidence (Axelson, Wårdh, Strender, & Nilsson, 2007; Leung et al., 2003).

Another form of mobile just-in-time learning are scenarios involving augmented reality. However, while developments such as Google's Goggles project appear to be promising, very little is known about how this technology can be harnessed for work-based education.

Bridging Individual and Social Learning

While the key functionality of mobiles is communication — that is, social interaction — it is surprising that so many mLearning solutions (such as the above case study from investment banking) are based on individual learning. This is all the more questionable in workplaces, since a great deal of competence development is rooted in “learning from other people” (Eraut, 2007).

In the IBM study described above, employees were accessing information sources on internal company networks in situ. However, when they lack information from these sources, they use their mobiles to involve subject matter experts, such as experienced colleagues who can help with immediate client query issues. Interestingly, the study also revealed that, compared with desktop PCs, employees were more likely to use their mobiles to communicate with “2nd- and 3rd-level individuals” — weak or loose connections outside their teams who were not originally intended to be the main points of contact. The IBM study also suggests that due to the ability of quickly locating colleagues, employees had an increased confidence level as well as an enhanced perception of their job performance.

Congruent findings (from the university context) report that the use of a social network site interacts with psychological well-being and helps in maintaining relations (in particular, weak ties) as people move throughout offline communities (Ellison, Steinfield, & Lampe, 2007). According to the network theory of “strength of weak ties” (Granovetter, 1973), weak connections can provide learners and organisations with particular work and learning opportunities as they facilitate the spreading of ideas and innovation beyond cliques or organisational units. This also seems to be in line with the importance that Hagel et al. (2009) attach to loosely coupled relationships “across large numbers of institutional entities so as to make them less transactional and more relational, ... and more supportive of richer cross-enterprise interactions and collaborations among their workers.” Such an approach could also be realised by means of “people tagging,” a particular

form of social networking. Cook and Pachler (2012), using case studies, describe how employees gather information about persons inside and outside a company by tagging “each other according to the topics they associate with this person” (2012).

All these examples illustrate how mobiles can connect individual learning and problem-solving with social interaction.

Bridging Informal and Formal Learning Contexts

Mobile devices are much more widely used for learning in informal contexts than in formal training contexts. However, these devices can be used well to connect informal learning at work with formal learning contexts such as teaching in classrooms or mentoring. Lufthansa, for example, created a course concept where junior managers received short tasks and assignments in the form of text messages directly at the workplace (very informal learning settings). The tasks aimed at applying theoretical knowledge from previous face-to-face workshops (more formal educational contexts). In a second message, learners were asked how well they were able to fulfil the task (Lison, 2004). While this is, from a technological standpoint, a very simple concept, and while there is no evaluation available, we deem it an interesting example of how mobiles can be used to recontextualise formal knowledge in informal settings.

Conversely, mobile devices can also be used to link informal, on-the-job learning with more formal educational settings. There are several examples from vocational studies where apprentices use mobiles to bridge workplace learning with mentoring or teaching in the classroom. For example, apprentices from different fields such as forestry, construction work, travel services, youth and leisure guiding, and catering used their mobiles to answer a daily question about their learning progress such as: “I have felt myself needed today” or “I have learned new things today” (Pirttiäho, Holm, Paalanen, & Thorström, 2007). The questions were disseminated, collected and analysed by the teacher. Students could also enrich their online diaries by taking pictures, videos and sound with their phones and then debrief about experiences in classroom settings. Evaluation reports suggest that such approaches are well received by students and can enhance education by setting learning goals and by supporting reflective practice and self-assessment (Mettiäinen & Karjalainen, 2011; Pirttiäho et al., 2007). Similarly, Coulby, Davies, Laxton, and Boomer (2011) and Coulby, Hennessey, Davies, and Fuller (2009) report how students use mobiles for formative self- and peer assessments during placements. Results are integrated in e-portfolios and allow students and tutors to discuss assessment and wider placement issues.

Bridging (Socio-) Cognitive, Cultural and Constructivist Perspectives

With all new technological developments, researchers and practitioners (desperately) try to measure cognitive effects, mostly in terms of better knowledge recall/retention. In view of the rich learning strategies involved, we consider this a somewhat limited and unpromising endeavour. Accordingly, one might wonder whether in the investment banking case study a “1.21 per cent increase in average competency score” (Swanson, 2008) justifies spending much additional resources in adapting eLearning content for mobile devices.

Beyond cognitive views, we suggest that the value of mLearning in work settings can be perfectly explained by socio-cognitive, situated and socio-cultural perspectives. Other studies report how, from the perspective of socio-cognitive approaches, accessing resources in support of work processes can foster situated learning and meaning-making (Pimmer, Linxen, & Gröhbiel, 2012), enhance learners' self-confidence and reduce uncertainty (Axelson et al., 2007; Leung et al., 2003). Documenting learning progress for formal assessments or for learning diaries can facilitate reflective practice, namely reflection in action and on action (Schön, 1983) as well as increase the level of feedback (Coulby et al., 2009; Coulby et al., 2011).

In our own work we have shown how medical trainees use mobile phones to document "situated experiences" (for example, in the form of multimedia material that they then use for individual study and reflection prior to exams, as well as to "proudly show it to the others" (Pimmer, Linxen, Gröhbiel, Jha, & Burg, 2012). This example emphasises the importance of social dynamics and links being situated in socio-cognitive learning with socio-cultural practices.

A number of examples demonstrate socio-cultural perspectives on mLearning in workplaces. Chan (2011, 2011), for instance, reports that documenting and sharing authentic multimedia evidence of experiences of work and at work enhanced apprentices' self-recognition, self-acceptance and processes of identity construction. Occupational identity trajectories — that is, the way one becomes a central member of a community of practice — were, inter alia, evidenced through the willingness with which apprentices showcased their e-portfolios to peers, their employers and the wider social communities. Wallace (2011) also revealed how learners collected evidence of their professional competences by creating, sharing and reflecting multimedia learning materials. In that way, identities of empowered learners were connected. Wallace posits that mobiles supported "making meaning and connection beyond the educational to the social."

Similarly, we have shown in our own work how learners use mobile phones and social networks to participate in international professional Facebook sites that allow for the announcement and negotiation of *occupational status* and professional identities (Pimmer, Linxen, & Gröhbiel, 2012). Social network sites and mobile devices can also help learners bridge social capital and, as shown in the IBM study, access "weak ties" that, in turn, provide learners and organisations with particular work and learning opportunities as they facilitate the spreading of ideas and innovation across organisational units (Ahmad & Orion, 2010; Ellison, Steinfeld, & Lampe, 2007). From the perspective of constructivist learning theories, several studies report how the creation of learning materials can support active knowledge construction and peer-to-peer learning (Brandt et al., 2005; Wallace, 2011).

Conclusion

Traditional forms of training and eLearning in workplace settings are based on the individual study of educationally structured content in relatively formal learning settings in order to help learners "acquire" knowledge for (potential) future use. In addition to these approaches, we have shown how affordances of mobile devices allow the realisation of rich pedagogical strategies. They enable cross-

contextual mLearning by bridging and connecting: (1) the creation and sharing of content such as multimedia material and digital stories in the form of audio, text, images and video; (2) learning *for* and learning *at* work (i.e., supporting competence development directly in the processes of work); (3) individual and social forms of learning (e.g., by means of social mobile networking, or the tagging and locating of experienced colleagues); and (4) education across formal and informal settings (e.g., by documenting on-the-job learning experiences by means of e-portfolios or reflective questions and discussing them in more formal classroom or mentoring settings).

By applying these strategies, the underlying educational design spans and connects situated, socio-cognitive, cultural, multimodal and constructivist perspectives of learning — moving the learner away from being a passive consumer to becoming an active producer and distributor as well as co-creator of multimodal designs and learning processes.

Traditional approaches to technology-enhanced learning tend to be sporadic and self-contained. In the initial case study for instance, time to completion and completion rates were measured (Swanson, 2008). The pedagogical strategies and empirical examples we have described in this chapter illustrate how the use of mobile devices and services can support learners across various phases of their identity and competence development, along career trajectories in and across new and changing contexts (see Table 14.2). This is an observation that is all the more important considering that competence development rarely occurs from one moment to another but evolves over time through connected learning experiences (Barnes, 2008). In this sense, mLearning in work-based education can bridge multifaceted learning contexts by involving various and rich educational approaches and paradigm.

Table 14.2: Contextual parameters to characterise work-based mobile learning

Contextual parameters	Traditional approaches	Enriched approaches: connecting contexts	Examples
Content	Delivery	Creation / sharing	<ul style="list-style-type: none">Producing and sharing of digital materials (audio, images, videos, text) of relevant work tasks
Proximity to work processes	Learning for work	Learning for work / learning at work	<ul style="list-style-type: none">Accessing of resources for immediate problem-solving in the processes of work on demand (pull)
Social form	Individual	Individual / social	<ul style="list-style-type: none">Social mobile networking, people tagging: creating loosely coupled expert networks and locating specialists for work challenges
Degree of formality	Formal	Setting: formal / informal	<ul style="list-style-type: none">Documenting of learning experiences/ formative assessment at work (e.g., mobile portfolios) and debriefing in classroom or mentoring settings
Educational paradigm	Cognitive, behavioural	Socio-cognitive, situated / social / cultural / constructivist and multimodal	<ul style="list-style-type: none">Situated learning, meaning-making, reflective practiceBridging of social capital, spreading of innovation/ ideas, peer-to-peer learning, active knowledge constructionIdentity formation, becoming a member of a professional community

In view of the limited scope of this chapter, we have been able to show only selective and (initial) empirical examples and to engage in rather limited

conceptual and theoretical discussions. While we have not been able to provide any definite accounts of the emerging field, we hope that we have offered a jumping-off point as well as guidance for future projects in order to more comprehensively “unlock” and harness the value of mobile devices for work-based education.

References

- Ahmad, N., & Orion, P. (2010). Smartphones make IBM smarter, but not as expected. *American Society for Training and Development 2010*.
- Attwell, G., Cook, J., & Ravenscroft, A. (2009). *Appropriating technologies for contextual knowledge: Mobile Personal Learning Environments*. Paper presented at the 2nd World Summit on the Knowledge Society (WSKS 2009), Crete.
- Axelsson, C., Wårdh, I., Strender, L. E., & Nilsson, G. (2007). Using medical knowledge sources on handheld computers: A qualitative study among junior doctors. *Medical Teacher*, 29(6), 611–618.
- Barnes, D. (2008). Exploratory talk for learning. *Exploring Talk in School*, 1–15.
- Bezemer, J., Jewitt, C., Diamantopoulou, S., Kress, G., & Mavers, D. (2012). Using a social semiotic approach to multimodality: Researching learning in schools, museums and hospitals. Working paper. Retrieved from <http://mode.ioe.ac.uk/2013/01/31/using-a-social-semiotic-approach-to-multimodality-researching-learning-in-schools-museums-and-hospitals-2/>
- Brandt, E., Hillgren, P.-A., & Björgvinsson, E. B. (2005). Self-produced video to augment peer-to-peer learning. In J. Attewell & C. Savill-Smith (Eds.), *Learning with mobile devices* (pp. 27–34). London: Learning and Skills Development Agency.
- Chan, S. (2011). Becoming a baker: Using mobile phones to compile e-portfolios. In N. Pachler, C. Pimmer, & J. Seipold (Eds.), *Work-based mobile learning: Concepts and cases* (pp. 91–117). Oxford, Bern, Berlin, Bruxelles, Frankfurt am Main, New York, Wien: Peter-Lang.
- Chan, S. (2011). Constructing of ePortfolios with mobile phones and Web 2.0. In *Enhancing learning through technology. Education unplugged: Mobile technologies and Web 2.0* (pp. 243–253), 6th International Conference on ITC, Hong Kong, China.
- Cook, J., & Pachler, N. (2012). Online people tagging: Social (mobile) network (ing) services and work-based learning. *British Journal of Educational Technology*, 43(5), 711–725.
- Coulby, C., Davies, N., Laxton, J., & Boomer, S. (2011). Mobile technology and assessment: A case study from the ALPS programme. In N. Pachler, C. Pimmer, & J. Seipold (Eds.), *Work-based mobile learning: Concepts and cases*. Oxford, Bern, Berlin, Bruxelles, Frankfurt am Main, New York, Wien: Peter-Lang.
- Coulby, C., Hennessey, S., Davies, N., & Fuller, R. (2009). The use of mobile technology for work-based assessment: The student experience. *British Journal of Educational Technology*, 42, 251–265.

- de Witt, C., Ganguin, S., & Mengel, M. K. S. (2011). Mobile learning in the process of work: Participation, knowledge and experience for professional development. In N. Pachler, C. Pimmer, & J. Seipold (Eds.), *Work-based mobile learning: Concepts and cases*. Oxford, Bern, Berlin, Bruxelles, Frankfurt am Main, New York, Wien: Peter-Lang.
- Ellison, N. B., Steinfield, C., & Lampe, C. (2007). The benefits of Facebook “friends”: Social capital and college students’ use of online social network sites. *Journal of Computer Mediated Communication*, 12(4), 1143–1168.
- Eraut, M. (2007). Learning from other people in the workplace. *Oxford Review of Education*, 33(4), 403–422.
- Evans, K., Guile, D., & Harris, J. (2010). Rethinking work-based learning – for education professionals and professionals who educate. In M. Malloch, L. Cairns, K. Evans, & B. N. O’Connor (Eds.), *The SAGE Handbook of workplace learning* (pp. 149–161). London.
- Grad, R. M., Pluye, P., Meng, Y., Segal, B., & Tamblyn, R. (2005). Assessing the impact of clinical information retrieval technology in a family practice residency. *Journal of Evaluation in Clinical Practice*, 11(6), 576–586.
- Granovetter, M. S. (1973). The strength of weak ties. *American Journal of Sociology*, 1360–1380.
- Hagel, J., Brown, J. S., & Davison, L. (2010). *Talent is everything*. Basic Book, USA.
- Harris, R., Willis, P., Simons, M., & Collins, E. (2001). The relative contributions of institutional and workplace learning environments: An analysis of apprenticeship training. *Journal of Vocational Education & Training*, 53(2), 263–278.
- Hug, T. (2009). *Microlearning: Examples, challenges, and conceptual considerations*. Paper presented at the Alpine Rendez-Vous: Technology-enhanced learning in the context of technological, societal and cultural transformation, Garmisch-Partenkirchen, Germany.
- Kraiger, K. (2008). Third generation instructional models: More about guiding development and design than selecting training methods. *Industrial and Organizational Psychology*, 1(4), 501–507.
- Leung, G. M., Johnston, J. M., Tin, K. Y. K., Wong, I. O. L., Ho, L. M., Lam, W. W. T., et al. (2003). Randomised controlled trial of clinical decision support tools to improve learning of evidence based medicine in medical students. *BMJ*, 327(7423), 1090.
- Lison. (2004). Konnten Sie die Aufgabe lösen? *Lufthanseat Mitarbeiterzeitschrift der Lufthansa*, 1038.
- Mettiäinen, S., & Karjalainen, A. L. (2011). *ICT-based software as a supervision tool in nursing students’ clinical training*. Paper presented at the 7th Advanced International Conference on Telecommunications. Retrieved from www.thinkmind.org/index.php?view=article&articleid=aict_2011_4_10_10017
- Pachler, N., Bachmair, B., & Cook, J. (2010). *Mobile learning: structures, agency, practices* (Vol. 1). New York Dordrecht Heidelberg London: Springer.

- Pachler, N., Pimmer, C., & Seipold, J. (2011a). Work-based mobile learning: An overview. In N. Pachler, C. Pimmer, & J. Seipold (Eds.), *Work-based mobile learning: Concepts and cases*. Oxford, Bern, Berlin, Bruxelles, Frankfurt am Main, New York, Wien: Peter-Lang.
- Pachler, N., Pimmer, C., & Seipold, J. (Eds.). (2011b). *Work-based mobile learning. concepts and cases*. Oxford, Bern, Berlin, Bruxelles, Frankfurt am Main, New York, Wien: Peter-Lang.
- Pimmer, C., & Gröhbiel, U. (2008). Mobile learning in corporate settings. Results from an expert survey. *mLearn2008. The Bridge from Text to Context*. Retrieved from www.christoph.pimmer.info/wp-content/uploads/2008/08/mobile-learning-in-corporate-settings.pdf
- Pimmer, C., Linxen, S., & Gröhbiel, U. (2012). Facebook as a learning tool? A case study on the appropriation of social network sites along with mobile phones in developing countries. *British Journal of Educational Technology*, 43(5), 726–738.
- Pimmer, C., Linxen, S., Gröhbiel, U., Jha, A., & Burg, G. (2012). Mobile learning in resource-constrained environments. A case study of medical education. *Medical Teacher*. doi:10.3109/0142159X.2012.733454
- Pimmer, C., Pachler, N., & Attwell, G. (2010). Towards work-based mobile learning: What we can learn from the fields of work-based learning and mobile learning. *International Journal of Mobile and Blended Learning*, 2(4), 1–18.
- Pirttiaho, P., Holm, J.-M., Paalanen, H., & Thorström, T. (2007). *Etaitava: Mobile tool for on-the-job learning*. Paper presented at the Iadis, International Conference on Mobile Learning, Lisbon, Portugal.
- Schön, D. A. (1983). *The reflective practitioner - how professionals think in action*. New York: Basic Books.
- Stead, G., & Good, M. (2011). Mobile learning in vocational settings: Lessons from the E-Ten BLOOM project. In N. Pachler, C. Pimmer & J. Seipold (Eds.), *Work-based mobile learning: Concepts and cases*. Oxford, Bern, Berlin, Bruxelles, Frankfurt am Main, New York, Wien: Peter-Lang.
- Swanson, K. (2008). Merrill Lynch: Bullish on mobile learning (case study). *Chief Learning Officer Magazine*. Retrieved October 14, 2012, from http://clomedia.com/articles/view/merrill_lynch_bullish_on_mobile_learning
- Wallace, R. (2011). The affordances of mobile learning that can engage disenfranchised learner identities in formal education In N. Pachler, C. Pimmer & J. Seipold (Eds.), *Work-based mobile learning: concepts and cases. A handbook for evidence based practice*. Oxford: Peter-Lang.
- Weekes, S. (2008). Mobile learning: Is anyone using it? Retrieved May 16, 2008, from www.personneltoday.com
- Woodill, G. (2012). Mobile McLuhan. The medium is the message: How McLuhan might have thought of mobile learning. Retrieved October 14, 2012, from <http://floatlearning.com/2012/08/mobile-mcluhan/>

Changing the Tunes from Bollywood's to Rural Livelihoods – Mobile Telephone Advisory Services to Small and Marginal Farmers in India: A Case Study

Balaji Venkataraman and T.V. Prabhakar

Abstract

A number of efforts are under way in the developing world to apply information and communication technology, particularly mobile telephony, to advance national and local development. Outreach in farming is far less influenced by such efforts. India is a case in point. In this chapter we look at two strands of development: one is agricultural growth and the other is growth in mobile telephony. India has a very large base of mobile subscriptions and a disproportionately smaller number of them are found in rural areas. Revenue from mobile value-added services in India is driven mainly by the sale of ring-back tones based on Bollywood tunes. Food production in India is carried out primarily by small and marginal farmers whose access to natural resources, credit and new production technologies is limited. The economic value of their contribution has tended to decline over the last two decades. Extension as a public service, which lost its pre-eminent position of the 1960s, needs to be bolstered. Reach of mobile telephony provides an opportunity because the numbers of experts in institutional milieu are unfavourable for conventional one-on-one training or on-farm demonstrations. A few initiatives are taking place, but their number and scale is not adequate to build compelling models.

We describe a new initiative called vKVK (KVK is an abbreviation of a Hindi name for Farm Science Centre). This initiative uses a wide range of open-source software to develop Web-to-mobile and mobile-to-mobile voice and text messaging applications. These are used by agricultural experts in KVKs to form interest or commodity-specific groups of farmers who regularly receive group-specific messages from the local expert. Activities take place over widely varied agro-ecological zones covering dozens of crops and across the three language regions of India. The suite of techniques is described. Call statistics and call status data are presented. Finally, vKVK as a scalable public service is analysed in the context of ongoing for-profit efforts.

Introduction

Use of contemporary information and communication technology (ICT) in national and local development has its own challenges of technology, process, and enterprise or organisational management. A number of studies reported in the conferences of IEEE-ACM (ICTD, 2012) and in journals (ITID Journal, 2012) provide examples of applications and challenges. Use of mobile telephony in the application of ICT in development is thought to confer some advantages over those that favour a PC-with-Internet approach (Samarajeeva, 2010). A few examples of successful deployment of mobile technology oriented towards local development are frequently cited in the global media, such as the mPESA in Kenya in recent times (The Economist, 2012) or the Grameen Telephone earlier (Cohen, 2006). However, there are no established models available for deployment of mobile telephony in support of food and livelihoods security in rural areas of the developing world, especially when multiple agro-ecological zones, cropping systems, and languages are involved. Food production by resource-limited, smallholder farmers is an area where the attention of global development investors is focused. The work of the Gates Foundation is one example of this (Bill & Melinda Gates Foundation, 2011). Despite such interest, few mobile/ICT-for-development initiatives exist in this area of development. Available ones certainly do not operate on a scale sufficient to build models with.

In the next sections, we describe a novel, ongoing mobile telephony initiative in India that covers about 20,000 farmers regularly in four states of India, in three different languages. There is significant variation in the range of agro-ecological zones and crops covered. A key aspect of this initiative is the way voice and text messaging is maintained independent of the carrier that the user is connected to or the handset/device that he or she makes uses of.

Outreach and Extension in Farming in India: Key Role of Farm Science Centres

Food production in India is carried out mainly by farmers and their families. There are a total of about 90 million farm households across the country (DAC, 2012). According to the Planning Commission of India, about 70% of the farms are below one hectare in size, and half the farmers are illiterate. Just 5% of the farmers have reached post-secondary stage in education. Women are increasingly taking to farming and, in the typical rural Indian context, are vulnerable to limitations in access to credit and services (Planning Commission, 2007).

Public agricultural extension service is an important arrangement to help such massive numbers of farmers interface with domain experts based in institutions. It also provides an opportunity for farmer education and training. During the Green Revolution era in the 1960s (when India's wheat production doubled in just one decade), on-farm demonstrations conducted by researchers were considered to have been particularly effective in training and enabling risk-averse and resource-poor farmers to adopt new production technologies on a massive scale (Swaminathan, 1971). To consolidate and advance those process gains, the Indian Council of Agricultural Research (ICAR, 2010) set up local Farm Science Centres, or Krishi Vigyan Kendras in Hindi (officially abbreviated KVK).

A KVK provides an interface between farmers and technologies for crop, animal and fisheries production developed in national research centres and state agricultural universities. Onsite technology demonstrations and training programmes for farmers are important activities in a KVK, while providing advisory and alert services to farmers is an essential function. Typically, a KVK may be managed by, and would be a part of, an agricultural university or a national agricultural research centre or a non-profit organisation. The ICAR stipulates the norms for the functioning of KVKs and provides a reasonable proportion of the operating funds. There are 630 KVKs functioning in India now.

Growth in agricultural production and agricultural GDP of India maintained a rate above the population growth well into the 1980s. There has been some volatility and decline in agricultural growth rates since then (Planning Commission, 2007). This has led to serious concerns about the continuing decline in the real income of farmers — about 48% of the farming households are in debt — and its potential impact on national food security.

The Indian National Commission on Farmers (NCF), in a series of reports during 2004–2006, recommended an elaborate set of measures to revitalise agricultural growth in India (with a focus on improving the well-being of farmers) and to mobilise greater public investments. One of its key set of recommendations relates to strengthening the extension system through bringing domain experts and farmers together in a more active mode of information and knowledge exchange using ICT (NCF, 2006). An independent study around this time, carried out by India's National Sample Survey Office (NSSO), covering 100,000 farm households, revealed that close to half of all farmers surveyed were accessing information on food production technologies and markets from relatives/friends and from local input dealers (NSSO, 2003). This study revealed that the KVKs were not being accessed by farmers as well as originally envisaged. In two different studies at a more micro-level (clusters of villages), a similar trend had been noted (Balaji, 2006).

Anticipating the potential inadequacies in the mostly person-to-person training and technology demonstration approaches, researchers thought that PC-based ICT services would have the power to usher in a new paradigm of computer-aided extension (CAEx, in the style of CAD/CAM) (Swaminathan, 1993). However, this had not been realised until as late as 2008. Although India had, by then, close to 10,000 active rural/village information centres equipped with PCs, few of those had an impact on agricultural extension processes that involve KVKs and farmers (Balaji, 2009).

Around this time, the ICAR launched a series of initiatives under its National Agricultural Innovation Project (NAIP, 2013), aimed at enhancing the capacity of national agricultural research centres and state agricultural universities to deploy contemporary ICT and Knowledge Management practices and improve research-education-extension linkages. The current initiative vKVK (vKVK, 2013), or Voice KVK in original expanded form, is part of the series of projects supported by the ICAR through its NAIP channel. Its thrust is on deploying mobile telephony services in support of KVKs' advisory services function, enabling experts and farmers to work in group-casing, interactive mode. This is anchored in the framework of Agropedia (Agropedia, 2013), which is a broad-based programme to build an ecosystem of semantically enabled applications in support of farming in India.

We shall briefly look at ongoing efforts and concerns in India's mobile telephony for the development sector while emphasising the unique character of vKVK: it is the only such project that links farmers and experts in agricultural universities and national research centres. Neither group of stakeholders needs to depend upon particular telecom service providers or handset manufacturers.

Mobile Value-Added Services and Mobiles-for-Development in India

India has a substantial base of mobile telecom subscriptions — about 950 million in the third quarter of 2012, according to the Telecom Regulatory Authority of India (TRAI, 2013). Besides this very large number, the speed of spread of mobile telephony in India is an important factor to note, with tele-density (number of telephone lines per 100 population) moving from under 4.38 in 2001 (Minges & Simkhada, 2002) to 67.67 in 2011 (ITU, 2011). The urban tele-density is thought to be over 100. The spread in rural areas is lower than in urban areas, and the TRAI estimates that the number of rural subscriptions as of June 2012 is between 150 million and 160 million. The rural population accounts for 68% of the total population, according to the Census of India (Census of India, 2011). A typical handset with a rural user is likely to be a basic instrument with voice and texting capabilities. Most such handsets cannot display characters in Indian languages, thus making voice the principal medium of use.

Telecom industry analysts have pointed to this disparity as an important opportunity for expansion of the industry. Analysts have also observed that the mobile telecom revenue derived in India is mainly based on voice usage. Data services do not offer a proportionately large stream of revenue because most businesses do not offer mobile data applications and services. The principal non-voice service for the industry is the sale of caller ring-back tones (RBTs) which enable a user to personalise his or her mobile presence in an affordable way (Ravishankar, 2012).

A very large proportion of RBTs are derived from Bollywood film music, hence the view that Bollywood has a role in the rapid spread of mobile telecom in India. A recent analysis of mobile value-added services in India shows that human development services, such as health alerts, do not find adequate numbers of customers, and telecom service providers are thus not keen on expanding into these markets. The need for such services in India, however, which is a country of ultra-poor people, is enormous. Here, then, is a case where market presence and profit orientation are not leading to the expansion of reach and servicing to those who need it most.

To their credit, telecom service providers and handset manufacturers have been offering a small range of development-oriented services tied to their particular brands of services or handsets. A significant example is the IFFCO Kisan Sanchar Limited (IKSL, 2013), which offers farmer messaging services to those who subscribe to Airtel (Airtel India, 2013), the largest telecom service company in India in 2012. The messages are generated by IFFCO (IFFCO, 2013), a public sector fertilizer company. Another example, Nokia Life, provides information services to rural users who purchase a particular range of Nokia handsets (Nokia, 2013). Device and telco-independent services — such as Reuters Market Light (RML, 2012), mKrishi (TCS, 2013), a suite of delivery-oriented applications for companies such as those selling inputs, and Ekgaon (Ekgaon, 2013) — have also been

launched in the last few years. This is a mix of large and small players, and we can infer that there is indeed space available for more rural-oriented value-added services for a variety of players, large or small.

The vKVK Initiative: Process and Technology

The vKVK, as noted earlier, is an effort to bring subject matter experts in agricultural extension centres together with farmers, using mobile telephony as the medium. Its uniqueness is in the fact that it is anchored in the institutional milieu of agriculture and is driven by domain experts, not by telecom service providers, handset manufacturers or software developers. The farmer is in focus. At the core of vKVK is the subject matter specialist in a KVK who has an intimate knowledge of local farming conditions in the area of coverage. It is often the case that the subject matter specialist knows many farmers and their practices personally and is engaged in facilitating formation of groups of farmers around specific interests or crops and commodities. One of the key features of the vKVK initiative is to enhance the expert's ability to facilitate the formation of farmers' groups. Experts at the KVKs are of the view that farmers respond better to group-specific messages than to globally broadcast messages. Another key feature is the capability of vKVK to provide a farmer with the facility to contact the expert based in the locality in order to resolve a query. This is important because farmers tend to value advice more if it is from a known and trusted human source, such as experts whom they know locally.

The vKVK initiative has been in regular operation since August 2011 and covers 97 KVKs in various states of India: Uttar Pradesh (Hindi), Uttarakhand (Hindi), Karnataka (Kannada), in the Telengana region of Andhra Pradesh (Telugu), and Gujarat and Kerala. Figure 15.1 shows the locations of these states.

The suite of techniques deployed in vKVK was developed entirely at the Indian Institute of Technology Kanpur (IITK). These include:

- a Web interface for the expert to create new groups of farmers by commodity/crop, locality or specific interest; or to add or change memberships in groups;
- a Web interface for an expert to record and/or upload an audio message (maximum of 60 seconds) and add subject-specific tags to it; and to set up schedules of delivery (including repeat calls if the called party is unavailable);
- a Web interface for an expert to create a text message in any of the three languages (Hindi, Kannada or Telugu); and to set up delivery options;
- a calling number for the expert to dial up and record a voice message for delivery to a group at a particular time or for immediate delivery (a single number is used across all the areas covered). This mobile-to-mobile arrangement, as it is known among the KVK-based experts, is proving to be popular, especially in the Hindi-speaking regions.
- a single number for any registered farmer to call an expert or to leave a voice message; based on the caller's location, the call is diverted to the expert in the "home" area of the farmer;

- all text and voice messages, together with tags, aggregated in a semantically enabled content aggregation platform, the Agropedia (Agropedia, 2013), which enables any expert to view and listen to messages (audio/text) he or she previously uploaded.

Figure 15.1: States of India where the vKVK project operates (lighter colour).



The schematic for the services architecture is shown in Figure 15.2 along with those for the Web-to-mobile and mobile-to-mobile services (Figures 15.3 and 15.4). The terms E2F (expert-to-farmer), F2E (farmer-to-expert) and E2E (expert-to-expert) are used in Figure 15.2. Screenshots of the expert’s Web console for creating and tagging messages are shown in Figures 15.5 and 15.6. All these services are hosted in, and operated by, IITK, which serves as the lead for the vKVK initiative.

Figure 15.2: vKVK services architecture.

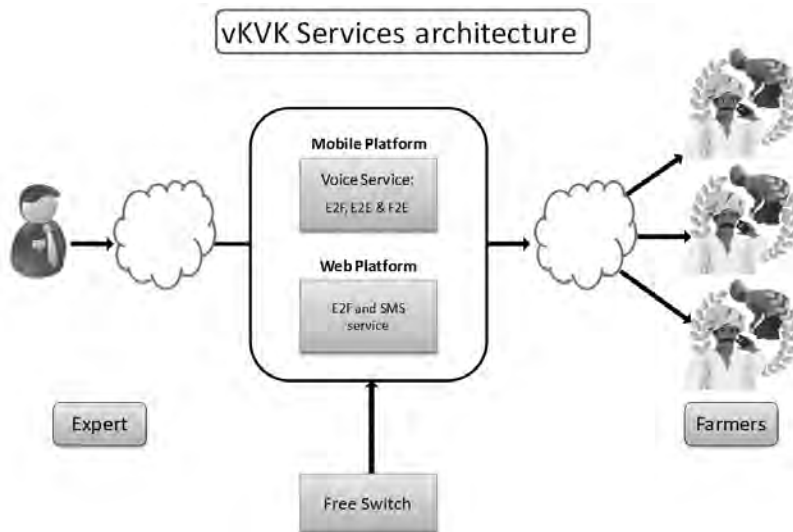


Figure 15.3: vKVK Web-to-mobile service architecture.

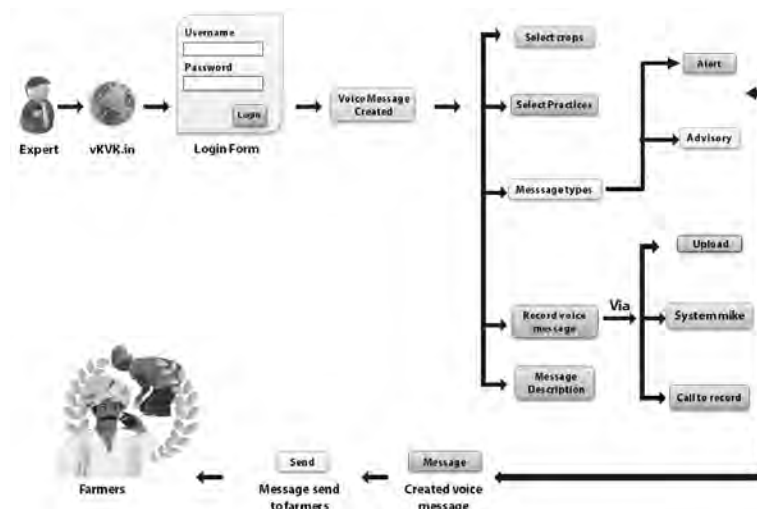


Figure 15.4: vKVK mobile-to-Web service architecture.

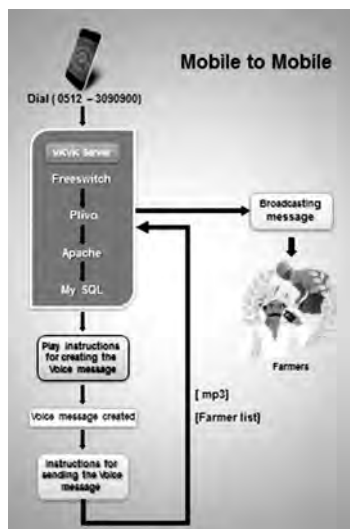


Figure 15.5: Web interface for the expert to create a text message for the farmer.

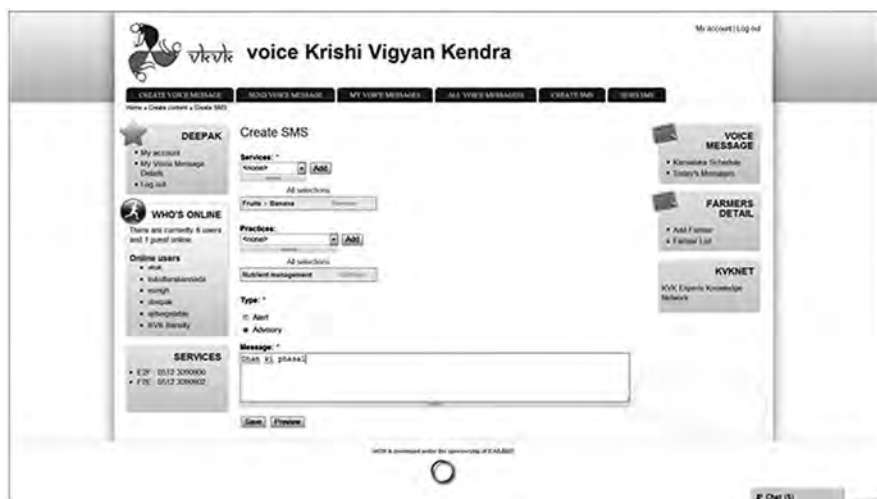
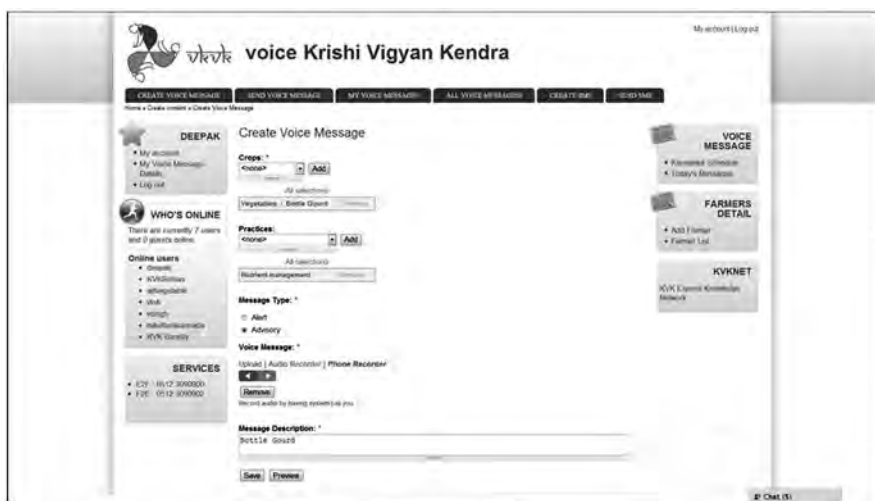


Figure 15.6: Web interface for the expert create or upload a voice message.



Launch of vKVK as a regular service in August 2011 was preceded by limited yet intensive trials for four months in 2010. The services were fine-tuned. A series of capacity-strengthening sessions was organised so that KVK-based subject matter specialists became conversant with the processes of registering farmers in groups and in recording messages to issue alerts or advisories. Although the original intent was to cover only 20 KVKs in the states of Uttar Pradesh and Uttarakhand, all of the 80 KVKs in these two states joined the initiative by late 2011. One subject matter specialist represents one KVK. There are 98 experts active as of November 2012, covering 97 KVKs (out of 630). The agro-ecological zones covered in these states range from alpine and sub-tropical regions in the Himalayas to dry, semi-arid tropical regions in South Central India.

As of November 2012, the number of farmers regularly using this service was 19,967. The range of crops and commodities covered over three cropping seasons is large: cereals – 9 (including wheat, barley, rice, maize, sorghum and pearl millet); pulses – 7; oil seeds – 8 (including groundnut/peanut and sunflower); vegetables – 16 (including beans, eggplant, cabbage and carrot); flowers – 7; fruits – 52; spices – 13 (including pepper and cinnamon); and plantation crops – 8 (including coffee, tea, cocoa and cashew). Livestock advisory services are focused on dairy cattle, pigs, small ruminants and poultry.

Data on calls made and texts sent is presented in Table 15.1. There is a regional variation in the number of calls and texts delivered to the farmers. The pick-up of services has been rapid in the State of Karnataka in South Central India, followed by Uttarakhand in the Himalayas. This is partly due to the fact that Karnataka is better served with telecom services, and the institutions there are faster in absorbing the combination of Web interface and mobile telephony in farmer communication. Data on status of voice calls is presented in Table 15.2. On average, about half the calls made from the KVKs to farmers are picked up. Regional variations are not unknown and analysis is in progress. Technology failure rate has been very low as measured in the number of Free Switch server crashes.

Table 15.1: vKVK operations (August 2012 – October 2013)

State	Number of farmers	Voice messages	Text messages
Karnataka	14,430	928,852	45,719
Uttar Pradesh	8,877	291,232	44,616
Uttarakhand	1,451	15,889	5,144
Andhra Pradesh	970	26,633	3,285
Rajasthan	1,492	23,754	--
Gujarat	757	11,019	--
Bihar	2,766	57,680	--
Kerala	1,140	13,336	--
Total	883	1,368,395	98,764

Table 15.2 : Status of call statistics: two consecutive months (2012)

Status of calls	Number of calls	% of total
Answered	75,968	48.76
Not answered	42,426	27.23
Failed	29,661	19.04
Busy	7,736	04.97
Total	155,791	100.00

Discussion and Conclusion

The vKVK project is in an early stage and methodologically rigorous impact studies will begin at the end of the cultivation season in early 2013. The impact analysis would include quantified data on satisfaction among farmers who used this service. Also of interest will be the number of small and marginal farmers, and women participants, since their participation in knowledge-sharing is considered a priority in policy planning. A key as well as immediate indicator of successful uptake is the number of domain experts who have signed up. It was expected that the number of KVK experts to sign up would be 28; the current number is much higher: 98. This compares favourably with IKSL, an older project of much larger financing, which has 53 experts registered. All the experts on vKVK offer services wholly for free and do not charge either the farmers or the project.

Agricultural knowledge in the Indian context has a prescriptive character. Although there is no explicit or formal regulation as to who can provide an alert or advisory, the norm is that the source of information is anchored in validated expertise. Even though there is no formal system to accredit or register agricultural practitioners as in medicine, institutional considerations and values are involved in identifying valid sources of knowledge. This is why securing the involvement of institutionalised expertise is critical in promoting viable knowledge-sharing practices in support of farming in India. The vKVK initiative has been successful in addressing this requirement from the launch stage and has gathered a wider following than originally envisaged.

Costs are also a consideration. As examples, the IKSL and the RML projects present two different business models: IKSL uses the clientele of a super-large telecom services provider through a commercial partnership; RML aims at revenue generation from user subscriptions. The university and research institution expertise is not directly linked to either of them as it is with the vKVK. The federal Planning Commission of India has stated that “extension should be treated as a service delivery mechanism and not be viewed as a revenue-generating program. Hence, the principles governing business models of a revenue-generating program should not be made applicable for extension services” (Planning Commission, 2007). In that spirit, vKVK has been funded by the ICAR to build and test an essential support service that contributes to increased awareness among farmers. However, as observed by an analyst of the telecom industry in India, the fund of the Universal Service Obligation (Government of India, 2002), collected by the federal government in India from telecom service providers, is close to USD 4 billion, with little being spent (Uppal, 2012). Farmer-oriented initiatives such as vKVK could perhaps draw upon that source as well, through an innovative public-private partnership in the spirit of public service.

Acknowledgements

This work is supported by the National Agricultural Innovation Project (NAIP) of the Indian Council of Agricultural Research (ICAR). A very large number of institutions and individuals are involved, and this case study at a preliminary stage is not the right place to list all of them. We would like to acknowledge the support of Meeta Bagga-Bhatia, Akhil Gupta and Virendra Singh (IIT-Kanpur) and Michelle Gruda (COL) in the development of this manuscript.

References

- Agropedia. (2013). Agropedia home. Retrieved from <http://agropedia.iitk.ac.in/>
- Airtel India. (2013). Airtel India home. Retrieved from www.airtel.in/wps/wcm/connect/airtel.in/airtel.in/home/?refid=0
- Attwell, G., & Baumgartl, B. (Eds.). (2009). *Creating learning spaces: Training and professional development for trainers*. Vol. 9. Navreime Publications, Vienna.
- Balaji, V. (2006). Agricultural extension. In R. K. Bagga, K. Keniston, & R. R. Mathur (Eds.), *State, IT and development*. New Delhi and London: Sage.
- Balaji, V. (2009). The fate of agriculture. *Seminar Magazine*, 597. Retrieved from www.india-seminar.com/semframe.html
- Bill & Melinda Gates Foundation. (2011). Agricultural development: Strategy overview. Retrieved from www.gatesfoundation.org/agriculturaldevelopment/Documents/agricultural-development-strategy-overview.pdf
- Blake, C., Adams, A., & Scanlon, E. (2011). *Effectiveness of mobile learning across various settings*. Paper presented at CAL Conference 2011, Learning Futures: Education, Technology & Sustainability, 13–15 April 2011, Manchester.

- Bradley, C., Haynes, R., Cook, J., Boyle, T., & Smith, C. (2009). Design and development of multimedia learning objects for mobile phones. In M. Ally (Ed.), *Mobile learning: Transforming the delivery of education and training* (pp. 157–182). Alberta: Athabasca University Press. Retrieved June 11, 2012, from www.aupress.ca/index.php/books/120155
- Bosavage, J., & Maselli, J. (2006). Are computers destroying the earth? Dr Dobb's. Retrieved October 22, 2012, from www.drdobbs.com/special-report-are-computers-destroying/186100362
- Census of India (2012). Census of India home. Retrieved from www.censusindia.gov.in/2011-common/census_info.html
- Cohen, J. (2006). Iqbal Quadir on TEDTalks: The impact one cell phone can make on a village... [Web log]. Retrieved from http://tedblog.typepad.com/tedblog/2006/10/iqbal_quadir_on.html
- Department of Agriculture and Cooperation (DAC) (2012). Statistics at a glance 2011. Department of Agriculture and Cooperation. Retrieved from <http://eands.dacnet.nic.in>
- Ekagaon. (2013). Ekagaon, one village one world home. Retrieved from www.ekagaon.com/CAM
- Government of India. (2002). Universal Service Obligation Fund. Ministry of Communications and Information Technology, Department of Telecommunications. Retrieved from www.dot.gov.in/uso/usoindex.htm
- ICTD. (2012). Papers and posters. Retrieved from <http://ictd2012.org/papers>
- IFFCO (2013). Indian Farmers Fertiliser Cooperative Limited home. Retrieved from <http://www.iffco.coop/>
- Indian Council of Agricultural Research (ICAR). (2010). ICAR home. Retrieved from <http://www.icar.org.in/>
- IKSL. (2013). IFFO Kisan Sanchar Limited home. Retrieved from <http://www.iksl.in>
- ITID Journal. (2012). Information Technologies and International Development. Retrieved from <http://itidjournal.org/itid>
- Indian Telecoms User (ITU). (2011, March 15). Indian Telecoms User base passes 800 million mark. [Web log]. Retrieved from www.itu.int/ITU-D/ict/newslog/Indian+Telecoms+User+Base+Passes+800+Million+Mark.aspx
- Minges, M. & Simkhada, P. (2002). A closer look at South Asia. *ITU News Magazine*. Retrieved from www.itu.int/itunews/issue/2002/10/southasia.html
- National Agricultural Innovation Project (NAIP). (2013). NAIP home. Retrieved from <http://www.naip.icar.org.in/>
- National Commission of Farmers (NCF). (2006). *Serving farmers and saving farmers*. Fifth and Final Report. Retrieved from <http://agricoop.nic.in/NCF/Revised%20Draft%20NPF%20of%20NCF.pdf>
- National Sample Survey Office (NSSO). (2003). *Access to modern technology for farming*. Report 499. New Delhi: Ministry of Statistics and Programme Implementation.

- Nokia. (2013). Progress Proj-Nokia Life Tools. Retrieved from <http://store.ovi.com/content/20650>
- Planning Commission of India (2007). Agriculture, Eleventh Five-Year Plan 2007–2012. New Delhi: Planning Commission of India. Retrieved from http://planningcommission.nic.in/plans/planrel/fiveyr/11th/11_v3/11v3_ch1.pdf
- Ravishankar, M. (Ed.). (2012). *Mobiles for development in India: Overviews of progress*. Workshop and Consultant's report. Vancouver: Commonwealth of Learning.
- Reuters Market Light. (2012). Reuters Market Light home. Retrieved from www.reutersmarketlight.com/index.html
- Samarajeeva, R. (2010). Mobile at the bottom of the pyramid: Informing policy from the demand side. *ITID Journal*, 7(3). Retrieved from <http://itidjournal.org/itid/article/view/756/316>
- Swaminathan, M. S. (1971). The purpose and philosophy of national demonstrations. *Indian Farming*, 21(6). Retrieved from <http://openagricola.nal.usda.gov/Record/CAIN729021401>
- Swaminathan, M. S. (Ed.). (1993). *Information technology: Reaching the unreachable*. Madras: Macmillan India.
- TCS (2013). mKRISHI Rural Services Delivery Platform. Retrieved from www.tcs.com/offerings/technology-products/mKRISHI/Pages/default.aspx
- The Economist (2012, August 25). Let us in. Retrieved from www.economist.com/node/21560878
- TRAI. (2013). Telecom Regulatory Authority of India home. Retrieved from <http://www.trai.gov.in/>
- Uppal, M. (2012). Delivering the full value of mobile networks in India. In M. Ravishankar (Ed.), *Mobiles for development in India: Overviews of progress*. Vancouver: Commonwealth of Learning.
- vKVK. (2012). Voice Krishi Vigyan Kendra. Retrieved from <http://vkvk.iitk.ac.in/>

The Future of Mobile Learning and Implications for Education and Training

David Parsons

Abstract

The future of mobile learning (mLearning) in education and training holds much promise, but it also poses many challenges and dangers. In imagining what mLearning may mean to us in the years to come, we should be wary of making predictions. Nevertheless, we can reflect on current and emerging technology and practice and usefully suggest how we might guide their future application and development. In doing so we should be careful not to ignore the lessons of the past, continuing to engage with the deeper questions about teaching and learning that will continue to underlie the application of learning technologies. This chapter is structured primarily as a series of “top fives” under different headings, intended to highlight some of the concerns of mLearning, both now and in the future. These cover mLearning myths and misunderstandings, mLearning innovations, and both the potentials and risks for mLearning in the future. Together these various perspectives on mLearning seek to provide an inclusive view of what mLearning means today, recognition of the best achievements of mLearning so far, and an agenda for the future that will, we hope, assist us in gaining the maximum benefits from mLearning while minimising the potential negative effects of technological, social and pedagogical change.

The Future Is Now

A few months ago, a student research assistant brought one of his home projects to show to a class, a robotic vehicle controlled by the orientation of a mobile phone. His current project is using off-the-shelf hardware to control the robot with brain waves. In a world where amateur student projects involve the mind control of robots, it is hard to look ahead without finding that one’s predictions are already part of everyday life.

With this caveat in mind, this chapter begins with a brief mobile learning (mLearning) scenario from a possible future.

Mobile learning as we approach the middle of the 21st century is just part of life. The old model of educational institutions has withered away, with learning now a lifelong, pervasive experience, delivered via the practically invisible devices that I have with me day and night, the personal network that delivers information to my eyes, ears and other senses, the e-glasses, the flexible smart-touch screen that folds into a small case but expands to poster size and will stick to or project onto any surface. These devices seamlessly connect and collaborate with ambient technologies in the environment. For example, in my informal learning activities related to photography, my camera will scan for nearby 3D printers to create models from my 3D photos. For my interest in literature, scenes from books play out in front of me if I happen to enter a location used by one of my favoured authors. For somewhat more formal learning, I attend immersive virtual reality classes whenever I want, mixing my avatar with those of other virtual students and both real and robot instructors. I learn when I need to, where I want to. When I am at work, I have professional learning support with me at all times, guiding me in new situations, online Artificial Intelligence systems reacting to my ever-changing contexts and giving me expert task and problem-solving support. I have all the knowledge ever gathered available in an instant, tailored to my own learning profiles and preferences, quality controlled by the world's best minds. Not that I am just bombarded with data. The mobile learning systems that I use are able to help me filter the huge amount of data in the computer cloud, assisting me in making meaning out of a mass of information, working with my own goals, learning styles and changing moods and activities to ensure that the material I am exposed to will help me learn rather than overwhelm me. As a mid-21st-century learner, I am never lost, never alone, never unsupported, never not learning.

If there is one thing that can be said for trying to predict the future, it is that we are bound to be wrong, at least if we try to go beyond very broad assumptions such as “the use of mLearning in education and training will increase.” We might therefore consider what the merits might be of attempting to look ahead to the future of mLearning, and the possible implications for education and training. Perhaps in doing so we might reflect on the idea that writing that purports to look to the future is often instead recasting the present through another lens. A classic example of this would be George Orwell's *1984*, the title of which a number of commentators, including Burgess (1978), have suggested is a partial inversion of the year the book was written (1948). Much science fiction follows similar themes, projecting current concerns either near or far into the future. Those who look at “near future” fiction and dismiss its inaccurate predictions (think *The Shape of Things to Come*, *2001, A Space Odyssey*, *Blade Runner* or even *Back to the Future*) miss the point that accurate prediction is not the purpose of such creative works. Rather, they hold a mirror up to the present that reflects the potential implications of our present actions.

Thus, this chapter does not propose to attempt accurate predictions of the future. Instead, it intends to reflect on the current technologies and affordances of mLearning, and consider which of these might continue to be useful to us in the future, as the worlds of work, learning, technology and society continue to evolve. In fact, the somewhat futuristic scenario above is based on the work of Golding (2008), who begins his book with a similar type of proposition based, as he makes clear, not on fantasy technology but by extrapolating from what we already have, here and now.

Top 5 Mobile Learning Myths and Misunderstandings

In an attempt to look ahead to the future of mLearning, one thing that may unnecessarily hold us back is making assumptions about what mLearning is, or what it could be, and so we could fail to appreciate its full set of potentials. This section lays out a “top five” of mLearning myths and misunderstandings. In doing so, it should be noted that these are not necessarily wrong; rather, they provide excessively limiting definitions of mLearning that do not serve us well in truly knowing what it means to be a mobile learner. In fact, in the examples that follow, we might easily insert the word “only” to make the point that these are all valid views of mLearning, but all are too restrictive to truly reflect what mLearning can be. In this section, we will take apart each of these myths and misunderstandings and explore how these definitions can limit our ideas about what can be achieved in mLearning.

Mobile Learning Is “Anytime, Anyplace” Learning

This is perhaps the most prevalent view of mLearning. The image is frequently used of commuters “learning” from a mobile device on the bus, on the train, etc. The limitation of this definition is that it focuses on the pervasiveness of the learning, but perhaps neglects the concept of mLearning at *this* time, in *this* place — in other words contextualised or situated learning (Seely Brown, Collins, & Duguid, 1989). One of the major affordances of a mobile device is that it can be brought to use in a specific context, a concept not acknowledged by “anywhere, anyplace.” To only follow this thread is to risk disconnected learning fragments, isolated from the reality around us.

Mobile Learning Is “Just In Time” Learning

There is nothing wrong with the concept of just-in-time learning. In fact, it is often used as the main justification for using mLearning in the workplace; the ability to get the information when and where you need it, at the point of delivery. The problem with just-in-time learning is that it potentially bypasses any concept of a curriculum, or a developmental frame within which learning takes place. It raises rather deeper questions about what we mean by learning. Is looking something up on the fly learning? Does it matter if you remember it or not (given that you can always look it up again)? This type of learning is sometimes called “performance support,” and perhaps this is how we should define it: not as learning, but as a tool to be used in the performance of various duties and responsibilities. Learning, we must assume, should go deeper than this.

Mobile Learning Is Learning While Mobile

This is an interesting misunderstanding, as it challenges us to consider what we mean by “mobile.” Is there an inherent expectation that the key to what we are doing is mobility? And what does mobility mean: Actually being in motion? Or being able to transition from place to place? We rarely learn while physically moving (leaving aside being in a moving vehicle) since the distractions are usually too problematic (Doolittle, 2009). What we tend to do is take our learning tools with us to the appropriate places. This raises the question: Do these learning tools need to be mobile devices? Or can we do mLearning with books, pens, paper, etc.? Indeed, in some experiments comparing mLearning solutions to paper-based solutions, it has been difficult to see the benefits of using the mobile device over the paper-based version (Fisher et al., 2012). Of course this will depend very much on the affordances that we require to deliver a particular type of learning. In some cases, traditional learning tools, in a learning context, will be able to deliver as much learning as any technology-based solution. In other cases, new technologies are essential to the activities.

Perhaps if there is confusion of perceptions here, it may be that some approaches to mLearning are seen as device centric whereas others are seen as learner centric. Both approaches, of course, have merit, but a learner-centric approach might tend to consider types of learning where the mobile device plays a minor role, whereas device-centric approaches are often those that push the boundaries of current tools exploring the new potentials of emerging and disruptive technologies (e.g., Ogata & Yano, 2010). It is interesting to consider Amit Garg’s “Top 7 Myths of Mobile Learning” (2012), and note how many of these myths are about technology rather than learning, including perceived issues with screen size, costs of creating and distributing content, security, fragmented platforms and SCORM compliance. Garg’s point is, perhaps, that we can easily get hung up on technological aspects of mLearning when these are not important barriers at all.

Mobile Learning Is an Extension of eLearning

There is a common approach to mLearning that is based on the mobilisation of existing eLearning systems, particularly learning management systems (LMS). An example of this would be mobile clients for the Moodle LMS. Many commercial eLearning providers have embraced the rush to HTML 5, keen to stress how the same content can be developed for desktop computers, tablets and smartphones. The problem with this approach is that the best that can be hoped for is content designed for eLearning adapted for a different form factor. It does not take into account any of the additional affordances of the mobile device, such as location awareness and both synchronous and asynchronous collaborative communication. “In reality, mlearning is different from elearning in terms of size of courses that can (or should) be delivered on mobiles; the context in which mlearning is accessed. Designers must consider the always on nature of phones which help capture the moment of creative learning and other such factors” (Garg, 2012).

Mobile Learning Is an Extension of Distance Learning

It is true that distance learners can benefit from mLearning. However, once again to regard the mobile device as only for use at a distance is to miss its opportunities for use in the classroom, where mobile applications can support learning processes. Indeed one of the major current movements in education worldwide is the integration of mobile devices, particularly tablets, into the daily life of the classroom. Some applications of mobile devices in the classroom have in fact seen them become embedded in the environment itself, thus becoming entirely static (e.g., Moher, 2006). Nevertheless, they still provide one form of mLearning, with mobile students using mobile devices that just happen to remain in one place.

To draw some ideas from these myths and misunderstandings about the future of mLearning in education and training, perhaps the main concern is that future mLearning tools may continue to use narrow definitions of what mLearning is (for example, just the mobilisation of an existing eLearning system) driven by the target markets of a particular vendor, or an emphasis on worker support tools by employers. To ensure that future mLearning systems meet their full potential, it is necessary that our understanding of mLearning encompasses all of its unique characteristics, and that we recognise that any form of learning that takes place using a mobile device is mLearning, whether on the move or static, whether in formal or informal settings, whether working collaboratively or alone.

Top 5 Mobile Learning Innovations

If the previous section took a somewhat negative viewpoint about myths and misunderstandings that might hold back the development of future mLearning, this section provides a more positive perspective of how mLearning is unique and powerful. In looking at the “top five” innovations describing the ground-breaking features of mLearning, we can see why definitions saying that mLearning is just an extension of eLearning or distance learning do not do it justice. It is important to note that these are not just technical innovations, but examples of how technology and pedagogy have been used together. Most (though not all) of the ways of learning listed below have an intimate relationship with the concept of mobility, emphasising the unique role that a mobile device can play in learning. In all cases, there are significant differences between these activities and traditional eLearning. Even where these are also standard learning activities (e.g., contributing to shared-learning resources), doing these things with mobile devices provides a much broader range of opportunities for gathering and exchanging knowledge with other learners and teachers.

Placing Learning in a Specific Context

One of the main affordances of a mobile device is that you can take it with you wherever you go. Much has been written about the importance of context in learning, to support situated cognition (Seely Brown et al., 1989). This idea has been much explored in mLearning projects, where the museum, the woodland or the city become meaningful locations for learning to take place. The great thing about having a modern mobile device is that it is a compendium of tools — an electronic Swiss Army knife. As such, once you are in a given context, it can help you to measure and analyse, to capture and publish, to organise and

communicate. This means, for example, that learners can apply mathematical or scientific inquiry in real-world problem-solving situations, using mLearning tools such as MobiMaths (Tangney et al., 2010).

Augmenting Reality with Virtual Information

With a mobile device, you can overlay something virtual onto something real. This has proved a very popular theme in recent mobile applications. Augmented reality tools such as Google Goggles, Wikitude and Layar show the potential for using a mobile device to give you information about artifacts, locations, etc. in areas as diverse as architecture, history and geography. Beyond these common tools, which overlay factual information onto what is physically present, there have been a number of mLearning applications where a virtual reality has been superimposed onto a physical location in order to provide a new learning experience. These include Savannah (Facer et al., 2004) and Invisible Buildings (Winter & Pemberton, 2011).

Contributing to Shared Learning Resources

One of the key themes of Web 2.0 is the concept that Web-based resources no longer work in one direction only (from a server to a client), but that users become their own content creators. A valuable aspect of learning is the ability to create new material and share it with others, for peer review and collaborative learning. Being able to do this with the assistance of a mobile device, which you can have with you in many contexts, broadens the range of sharing opportunities. It also further enhances the concept of bricolage and diverse learning ecologies (Seely Brown, 2000), in this way making meaning out of the digital artifacts we create from the physical and conceptual learning moments that we constantly encounter. The ability to learn while communicating and contributing at a distance with other learners supports the concept of distributed cognition (Hutchins, 1995). While the initial work in this area found this distribution to be among groups physically co-located, the concept also includes communication with others at a distance. An early example of this type of mLearning can be seen in the distributed collaborative field work described in the Wireless Coyote project (Grant, 1993).

Having an Adaptive Learning Toolkit in the Palm of Your Hand

A mobile device is increasingly a toolkit. As well as the tool-like functions that are built in to the device hardware (camera, sound recorder, video recorder, multimedia messaging, etc.), there are also many applications that can take advantage of various combinations of functions and sensors to make the phone into all kinds of tool. Your mobile can be a distance-measuring device, a guitar tuner, a musical instrument, a compass, a speedometer, a spirit level, and a whole range of other things. This allows the device to be adapted for use as a supporting tool in an almost infinite range of learning activities. In particular, the role of device as tool is well suited to supporting inquiry-based learning (Powell et al., 2011). Whether being used as a support tool to scaffold learning in the classroom or as a means to capture learning experiences in the field, there will be some kind of hardware and/or software feature that can be utilised in the learning process.

Taking Ownership of Learning

One of mLearning's most significant innovations has to do with the ownership of personal learning devices. The personal digital device gives learners the ability to appropriate and personalise their own learning experience, to autonomously acquire the learning material that they want, whenever and wherever they wish to do so. Equally, they have the ability to capture their own learning moments (take photos, videos, notes) and share their insights or questions with others using social media and LMS. Emphasising the personalisation of learning, Sergio (2012) notes that "'m' usually stands for 'mobile' but also just as easily for 'me.'" He further acknowledges the importance of accessibility, noting that mLearning opens access to all kinds of people who previously had limited access to learning, in particular in areas of the globe where some members of society have had no previous access to any technologies that could support learning.

To reflect on the innovations covered in this section, we can see that mLearning encompasses learning that is situated, collaborative and adaptive. In addition, it provides for augmented and virtual realities that provide learning opportunities that go beyond physical environments. Increasing accessibility also means that mLearning can be for the many, not just the few. In the future, we can look forward to these themes developing more broadly and becoming more pervasive. Future mobile learners will have devices that can act as all kinds of learning tools, simulating and supporting all kinds of learning environments, and providing access to mLearning for all, regardless of their location, culture or socio-economic status.

Top 5 Future Potentials for Mobile Learning

Perhaps the most important aspect of a chapter looking at the future of mLearning is to look forward to its main potentials. These are based primarily around the increasing power and pervasiveness of mobile devices, and their mass integration into the world of teaching and learning.

All Students in a Class Can Use Their Own Device for Learning

Perhaps the defining characteristic of mLearning in the second decade of the 21st century is that the Bring Your Own Device (BYOD) approach has suddenly become the norm rather than the exception. This opens up major new opportunities for digital learning in the classroom, since the old constraints of having to provide all learning technologies from central resources gradually fade away. Not that central resources are no longer required, since networks and cloud-based services become even more essential, but enabling a learner's own devices to be used for learning leads to greater efficiencies and digital inclusion.

We Capture Existing Technology and Best Practice for Learning

We should always be wary of reinventing the wheel. Educational research, including research into educational technology, has a long history and we would be foolish to embark on new technology-driven interventions in the classroom without taking full account of what we have learned in the past, and already understood about the processes of teaching and learning. The balance that needs

to be struck is between embracing new ways of teaching and learning that are afforded by mobile devices, while holding to the underlying principles of good education. One very positive aspect of mobile technology is that it allows us to share the very best of existing practice using mobile technology. A good example of this would be the O2 Learn website (O2, 2012), which provides not only a video-sharing website for categorised educational content, but a tailored mobile app for easily capturing and uploading this content directly from the learning context.

Everything We Want to Teach Can Have a Mobile App

To some extent this is probably true already. Indeed, in some cases there are more apps (and other learning resources) for a given topic than you could possibly absorb. How many applications and websites teach basic mathematics, for example? We have seen the rise of online initiatives such as iTunesU and the MOOC (massive open online course) phenomenon, all of which threaten to overwhelm us with quantity without necessarily giving us the means to select the right applications for our own teaching or learning purposes. However, we can assume that over time the wisdom of crowds will assist us in finding the most suitable apps for a particular learning content; that, over time, the best apps will go viral while the weaker offerings fall by the wayside.

We Re-engage Students by Integrating Mobile Technologies into the Classroom

Lecture attendance in non-compulsory education has never been 100%, but gradually we have been eroding the reasons why students should come to class, particularly to large lectures (as opposed to smaller workshops, seminars, labs, etc.) by adopting LMS that often do no more than host a mass of uncontextualised material. The alternative to this is that we rethink our pedagogy by integrating mobile technologies so that face-to-face classes, even in large lecture halls, can become engaging and productive. We have already seen initiatives such as clickers and the “flipped classroom.” However there is huge potential to do much more in transforming our teaching philosophy to embrace mobile technologies in the classroom. The recent surge in BYOD initiatives suggests that many educators see the potential of mLearning as part of regular classroom delivery.

We Teach Things in a Practical Way That Could Previously Only Be Taught Theoretically

One of the major potentials of learning technologies is that they enable us to provide access to learning experiences that were previously too expensive, complex, dangerous or specialised to provide. We can now overcome these limitations by connecting learners to remote learning activities. It is already the case that distance students can perform engineering experiments remotely using remote data connections (Toole, 2011). Indeed, such virtual interactions need not take place only with physical contexts but also virtual contexts, performing experiments in virtual worlds (Vallance, Martin, Wiz, & van Schaik, 2010). As mobile technologies become more pervasive and seamless, new opportunities will arise for us to create practical learning experiences, accessed remotely through mobile devices.

In general, the future potential for mLearning is to enhance learning both inside and outside the classroom and workplace. By bringing devices into the classroom, we have the opportunity to transform formal education into a more engaging, relevant, collaborative and outward-facing activity. By taking learning outside the classroom using mobile devices, we have the opportunity to transform informal education, by turning the whole world into a learning space.

Top 5 Future Risks for Mobile Learning

While we are looking ahead, it would be unwise to focus only on the potential positives. We also need to guard against possible negative impacts. Some of the most important of these are outlined in this section.

Entrenched Digital Divides

Any approach to learning that involves technology may have an impact on digital divides. These divides can be quite subtle. They relate not only to access to equipment and connectivity, but also to the skills to make use of that equipment, and other aspects of the learners' situation that may impact on their ability to make meaning, to appropriate and to contribute. Wei, Teo, Chan, and Tan (2011) defined three levels of digital divide: the digital access divide, the digital capability divide and the digital outcome divide. Each influences the next and has an impact on learning. The message here is that we cannot address digital inequality just by providing access to technology. In addition, we need to address many aspects of digital literacy and digital citizenship.

Digital Distractions and Threats

Many schools have sought to ban mobile devices from the classroom on the grounds that they are purely distractions. For example, Greenwich Free school in London states in its public documents that "Mobile phones are a huge distraction in lessons, with pupils thinking about text-messaging, Twitter or Facebook in class instead of their work" (Greenwich Free School, 2012). This school is by no means unusual in this policy. In addition, fears about theft of devices and cyber-bullying exist too. A further dimension to distraction is the potential for information overload, distracting us from our learning objectives. We want to make meaning, not just accumulate data (Shum & Crick, 2012).

The Opposite of a Green Manifesto

Already there are more computers in landfill sites than on the desktop, and we continue to turn the planet to trash at a frightening rate. Every year, hundreds of millions of electronic items go to landfill in the United States and, globally, tens of millions of tons of e-waste go to landfill. To compound the problem, mobile phones have a particularly short lifespan. "Cellular contracts are 2 years for a reason; it takes approximately 1 year to recoup the costs of marketing, manufacturing, activating, and maintaining a cell phone, and the average cellphone lasts only 2 years. Battery life spans average 18 to 30 months" (Walker, 2010).

Even where electronic material is recycled, the impacts on developing countries can be disastrous, with dangerous recycling practices poisoning individuals

and the environment (Bosavage & Maselli, 2006). Although many aspects of this negative environmental impact may be out of our direct control, we should nevertheless attempt to make wise choices in the purchase and use of mobile devices for learning, preferring devices that have low power consumption and a long service lifetime (e.g., have maintainable components), and that can be safely recycled — even if these may be more expensive to purchase in the first instance.

Uncontrolled, Misleading Effects on Outcomes

One of the issues facing us in evaluating the value or otherwise of mLearning is that we may find it hard to measure the real, as opposed to the perceived, impacts of new technologies. There are two well-known types of effect that can lead to false positives in assessing changes in practice or new forms of presentation. Various proposed effects, such as the “Hawthorne effect,” suggest that it is hard to directly measure the real benefit of a change to a learning process because the context of the experiment itself may have effects that are separate from the actual intervention. The other effect that might be relevant is the “Dr. Fox effect,” which is where people tend to give more value to something that is well presented regardless of the real value of the content being presented (Naftulin, Ware, & Donnelly, 1973).

Whilst the original Dr. Fox experiment, where an actor posing as an academic gave a highly engaging but meaningless lecture to a great reception, would now be hard to repeat without a considerable amount of fake material being posted on the Web, the same effect might be seen in the tendency for many student researchers to regard Wikipedia as the default first port of call for information and, further, to cite it with an uncritical eye. Thus, we should be careful not to allow the allure of new technologies and novel activities to suggest real teaching and learning benefits that may not really be present. We still have much to learn about instructional design, as new technologies present new challenges. In assessing new strategies, we must be mindful of drawing the right conclusions (Merrill, 2007).

Poor Return on Investment

Much literature (e.g., Brynjolfsson & Yang, 1996) has concerned itself with the “IT productivity paradox,” referring to the elusiveness of productivity returns from information technology (IT) investments. Remarkably, it seems to be very hard to see where the return on investment comes from with IT. Whilst that debate is complex and ongoing, we should at least acknowledge that return on investment in learning technologies (indeed, any form of educational investment) is very important. Investment in education should see a return in terms of learning taking place, whether in a public school system, a university, or a corporate training environment. Large investments in educational technologies take funding away from alternative investments in education. It is therefore essential that the return on investment in any form of mLearning be at least as valuable as alternative forms of educational investment.

Researchers are failing in their duty if they do not consider what negative outcomes might flow from their work. Those of us who wish to promote mLearning need to be aware of its impacts on individuals, organisations and the

environment that may be negative, and attempt to mitigate these. In addition, we need to ensure that our research methods are rigorous enough to avoid false positives, and ensure that any benefits we claim are in fact real.

Conclusion

Attempting to predict the future is an uncertain business, but an essential characteristic of the researcher is an interest in looking ahead to what we might be able to achieve. By addressing some major issues in mLearning as a series of “top fives,” this chapter has attempted to contextualise both current and future concerns from both positive and negative perspectives.

- In addressing myths and misunderstandings, the chapter has outlined the areas where mLearning has been characterised in limited and unimaginative terms. By being aware of these assumptions, we may be able to more fully exploit mLearning in the future.
- In addressing mLearning innovations, the chapter has explored the broad range of affordances that are now offered by the types of mobile devices that are widespread in the learner community.
- In addressing future potentials, the chapter has shown how such technological progress, coupled with imaginative approaches to teaching, can bring true innovation to the classroom and to learning experiences in the wider world.
- Finally, in addressing possible future risks for mLearning, the chapter has attempted to raise awareness of potential negative effects, to assist researchers and educators in avoiding possible pitfalls of mLearning innovation.

In this chapter, we have seen the past contributions of mLearning, its most innovative characteristics, and some of its potentials and risks for the future. Whatever developments may come in technology and pedagogy, it is certain that the concept of mobility will have an increasingly important role to play in lifelong learning, as our experiences as learners and with the supporting technologies become more fluid, adaptive, collaborative and exploratory.

References

- Bosavage, J., & Maselli, J. (2006). Are computers destroying the earth? Dr Dobb's. Retrieved October 22, 2012, from www.drdoobs.com/special-report-are-computers-destroying/186100362
- Brynjolfsson, E., & Yang, S. (1996). Information technology and productivity: A review of the literature. *Advances in Computers*, 43, 179–214.
- Burgess, A. (1978). 1985. London: Hutchinson.
- Doolittle, P. (2009). iPods as mobile multimedia learning environments. In H. Ryu & D. Parsons (Eds.), *Innovative mobile learning: techniques and technologies*. Hershey, PA: IGI Global.

- Facer, K., Joiner, R., Stanton, D., Reidz, J., Hullz, R., & Kirk, D. (2004). Savannah: Mobile gaming and learning? *Journal of Computer-Assisted Learning*, 20, 399–409.
- Fisher, F., Sharples, M., Pemberton, R., Ogata, H., Uosaki, N., Edmonds, P., Hull, A., & Tschorn, P. (2012). Incidental second language vocabulary learning from reading novels: A comparison of three mobile modes. *International Journal of Mobile and Blended Learning*, 4(4), 47–61.
- Garg, A. (2012). Top 7 myths of mobile learning. *Upside Learning*. Retrieved October 22, 2012, from www.upsidelearning.com/blog/index.php/2012/07/05/top-7-myths-of-mobile-learning/
- Golding, A. (2008). *Next generation wireless applications: Creating mobile applications in a Web 2.0 and mobile 2.0 world*. 2nd ed. Chichester: Wiley.
- Grant, W. (1993). Wireless Coyote: A computer-supported field trip. *Communications of the ACM*, 36(5), 57–59.
- Greenwich Free School (2012). *Mobile phones Q&A for parents*. Retrieved October 22, 2012, from www.greenwichfreeschool.co.uk/documents/GFS_Q_As_mobile_phones.pdf.
- Hutchins, E. (1995). *Cognition in the wild*. Cambridge, MA: MIT Press.
- Merrill, M. (2007). The proper study of instructional design. In R. Reiser & J. Dempsey (Eds.), *Trends and issues in instructional design and technology*. 2nd ed. (pp. 336–341). Pearson Prentice Hall.
- Moher, T. (2006). Embedded phenomena: Supporting science learning with classroom-sized distributed simulations. In *Proceedings of CHI 2006* (pp. 691–700). ACM Press.
- Naftulin, D., Ware, J., & Donnelly, F. (1973). The Doctor Fox lecture: A paradigm of educational seduction. *Journal of Medical Education*, 48, 630–635.
- O2 (2012). *O2 learn*. Retrieved October 22, 2012, from <https://www.o2learn.co.uk/>
- Ogata, H., & Yano, Y. (2010). Supporting awareness in ubiquitous learning. *International Journal of Mobile and Blended Learning*, 1(4) 1–11.
- Powell, C., Perkins, S., Hamm, S., Hatherill, R., Nicholson, L., & Harapnuik, D. (2011). Mobile-enhanced inquiry-based learning: A collaborative study. *Educause Review*. Retrieved October 22, 2012, from www.educause.edu/ero/article/mobile-enhanced-inquiry-based-learning-collaborative-study
- Rogers, Y., Price, S., Randell, C., Fraser, D., Weal, M., & Fitzpatrick, G. (2005). Ubi-learning integrates indoor and outdoor experiences. *Communications of the ACM*, 48(1), 55–59.
- Shum, S., & Crick, R. (2012). Learning dispositions and transferable competencies: Pedagogy, modelling and learning analytics. In *Proceedings of LAK'12* (pp. 92–101). Vancouver, BC, Canada: ACM Press.
- Seely Brown, J. (2000). Growing up digital: How the web changes work, education, and the ways people learn. *Change*, March/April 2000.
- Seely Brown, J., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher*, 18(1), 32–42.

- Sergio, F. (2012). 10 ways that mobile learning will revolutionize education. Retrieved October 22, 2012, from www.fastcodesign.com/1669896/10-ways-that-mobile-learning-will-revolutionize-education
- Tangney, B., Weber, S., O'Hanlon, P., Knowles, D., Munnelly, J., Salkham, A., Watson, R., & Jennings, K. (2010). MobiMaths: An approach to utilising smartphones in teaching mathematics. In M. Montebello, V. Camilleri, & A. Dingli (Eds.), *MLearn 2010 Mobile Learning, Proceedings of 9th World Conference on Mobile and Contextual Learning* (pp. 9–15). University of Malta.
- Toole, T. (2011). Social media: Key tools for the future of work-based learning. *Development and Learning in Organizations*, 25(5) 31– 34.
- Vallance, M., Martin, S. Wiz, C., & van Schaik, P. (2010). Designing effective spaces, tasks and metrics for communication in Second Life within the context of programming LEGO NXT Mindstorms™ Robots. *International Journal of Virtual and Personal Learning Environments*, 1(1), 20–37.
- Walker, J. (2010). How to identify the lifespan of a cell phone. *eHow*. Retrieved October 22, 2012, from www.ehow.com/how_7495298_identify-lifespan-cell-phone.html
- Wei, K., Teo, H., Chan, H., & Tan, B. (2011). Conceptualizing and testing a social cognitive model of the digital divide. *Information Systems Research*, 22, 170–187.
- Winter, N., & Pemberton, L. (2011). Unearthing invisible buildings: Device focus and device sharing in a collaborative mobile learning activity. *International Journal of Mobile and Blended Learning*, 3(4) 1–18.

Glossary

4G: The newest generation of mobile communications technology; allows data transfer to and from mobile devices at rates between 15 and 100 times faster than 3G networks

Advanced Distributed Learning (ADL) Initiative: One of several standardisation efforts in the field of technology-enhanced learning; see more at Advanced Distributed Learning

aggregation: The collection and integration of different data sources

ambient displays: Embedded indicators in everyday artifacts. Ambient displays can use multimodal information encoding as visual, auditory, haptic, gustatory or olfactory modalities.

ambient information: Information that is ubiquitous and embedded in every environment via the use of ambient displays

Ambient Information Channel (AICHE): A model and a methodology to design mobile applications and user interfaces that consider context of use. The AICHE focuses on designing integrated experiences that synchronise user services provided by mobile technology with the resources in the user's environment, situation or context.

app: Short form of *mobile application*

app market: A digital application distribution method designed to provide application software to users

Application Programming Interface (API): The specification of how the different software in a system should interact with each other to produce the desired outcome

artifacts: Physical objects in the environment of the user. These can be used as input and output channels and handlers for manipulating or perceiving ambient information.

audiobook: A recording of a text being read. It is not necessarily an exact audio version of a book or magazine.

augmented reality (AR): A live direct or indirect view of a physical, real-world environment whose elements are augmented by computer-generated sensory input such as sound, video, graphics or GPS data

blended learning: Education that combines face-to-face classroom methods with computer-mediated activities

Bluetooth: A short-range radio technology aimed at simplifying communications among Internet devices, and between devices and the Internet

bricolage: A concept that comes from the work of Claude Lévi-Strauss. It relates to finding resources (objects, tools, documents, etc.) and applying judgement to use them to build something you believe is important.

BYOD (Bring Your Own Device): In a learning scenario, means allowing learners to use their own personal devices

cellular: Frequency allocated for digital communications. Competing cellular systems include GSM and CDMA.

channel or ambient information channel: A two-way interaction channel for ambient information through which the user can interact with information in his or her environment or context

Code Division Multiple Access (CDMA): A digital wireless 2G technology that uses a spread spectrum technique to scatter a radio signal across a wide range of frequencies. CDMA carriers include Sprint, NexTel, Verizon, Alltel and Telus.

constructivist learning: Knowledge that develops through interactions with the environment

context: The situation or environment of the user. The literature distinguishes five main types of context in *AICHE*: identity, time, location, activity and relations.

cross platform: A technical approach to building software once, but allowing it to run on multiple operating systems

CSS (Cascading Style Sheets): A style language that describes how HTML mark-up is presented or styled. CSS3 is the latest version of the CSS specification.

DAISY (Digital Accessible Information System): A technical standard for digital audiobooks, periodicals and computerised text. DAISY is designed to be a complete audio substitute for print material and is designed specifically for use by people with “print disabilities” such as blindness, impaired vision, and dyslexia.

discovery learning: Knowledge discovered through active participation in the learning process

distance learning: A mode of delivering education and instruction, often on an individual basis, to students who are not physically present in a traditional setting such as a classroom. Distance learning provides access to learning when the source of information and the learners are separated by time, distance or both.

distributed cognition: The social aspects of learning, with the learner being in a relationship with physical things and other people in the environment

DITA (Darwin Information Typing Architecture): An XML standard that supports structured development and flexible delivery of documentation

educational technology: The study and ethical practice of facilitating learning and improving performance by creating, using and managing appropriate technological processes and resources

eLearning: All forms of electronically supported learning and teaching, including educational technology. The information and communication systems, whether networked learning or not, serve as specific media to implement the learning process.

EPUB (electronic publication): A free and open e-book standard of the International Digital Publishing Forum (IDPF). Files have the extension .epub. EPUB is designed for reflowable content, meaning that an EPUB reader can optimise text for a particular display device.

Experience API: The first project of the Training and Learning Architecture (TLA) effort of the *Advanced Distributed Learning (ADL) Initiative* to further the *SCORM* effort

Extensible Markup Language (XML): A mark-up language that defines a set of rules for encoding documents in a format that is both human-readable and machine-readable

findability: Within the usability and user experience communities, refers to the ease with which *mobile app* users can locate the specific content they seek

flexible learning: Making learning resources and methods increasingly distributed, varied and personalised across temporal and spatial spaces

flipped classroom: The use of online media to move the direct instruction aspects of education out of the classroom, and to use face-to-face time for more interactive, exploratory activities. The term was originally conceived by teachers Jonathan Bergman and Aaron Sams in the United States.

formal learning: Learning that takes place in formal educational settings

framing: The process of putting ambient information into a context and displaying pedagogically relevant frames or contextual information for stimulating learning processes

geocaching: A treasure-hunting game using a GPS to search for and hide containers (geocaches)

Global System for Mobile Communications (GSM): A 2G technology that is the de facto European standard for digital cellular telephone service, and is also available in the Americas. GSM carriers include AT&T, T-Mobile, SunCom and Rogers.

GPS (Global Positioning System): A worldwide satellite navigational system generally used for navigation and location determination

hashtag: The # symbol on a keyboard, used for *microblogging* purposes to add a meaningful tag to specific content

HTML (HyperText Markup Language): The mark-up language of the Web

HTML5: The latest iteration of HTML. It includes new features, improvements to existing features, and scripting-based *APIs*. It is designed to work on just about every platform and has been adopted by most mobile phone browsers. It provides for offline storage and does not require plug-ins.

IMS Learning Design (IMS LD): A formal technical specification proposed by the IMS Global Learning Consortium that defines a notation language for describing learning designs. It is based on the Educational Modeling Language proposed by the Open University of Netherlands (OUNL).

information and communications technology (ICT): A synonym for information technology (IT), but which is broader and stresses the role of unified communications and the integration of telecommunications (telephone lines and

wireless signals) with computers (including the necessary enterprise software, middleware, storage and audio-visual systems) to enable users to access, store, transmit and manipulate information

informal learning: Learning that takes place autonomously and casually

instructional design, or educational design: Descriptive model of educational processes

iPad: A type of *tablet* computer designed and marketed by Apple Inc.

iPhone: A type of *smartphone* designed and marketed by Apple Inc.

iPod: A type of portable media players designed and marketed by Apple Inc.

JavaScript: Programming language, part of the HTML5 framework

learning design: In reference to the teaching-learning process, the specific pedagogical strategy or practice that takes place within a unit of learning (e.g., an online course, a learning activity or any other designed learning event), aimed at addressing specific learning objectives for a specific target group in a specific educational context

learning orchestration system: A learning operating system that supports the implementation of educational designs

learning management system (LMS): The system that co-ordinates the activities when learners complete online, eLearning and mobile learning courses. The LMS administers the learning process, delivers the learning materials, tracks learners and allows learners to interact with the teacher and with other learners.

location-based learning: Learning that is connected to the physical location of a student

microblogging: A broadcast medium in the form of blogging. A microblog differs from a traditional blog in that its content is typically smaller in both actual and aggregate file size. Microblogs allow users to exchange small elements of content, such as short sentences, individual images and video links.

mLearning (mobile learning): All forms of learning that happen when the learner is not at a fixed, pre-determined location; also refers to learning that happens when the learner takes advantage of the learning opportunities offered by mobile technologies

mobile application (mobile app): A software application designed for use on *mobile devices* (such as *smartphones* and *tablets*)

mobile device: A small, hand-held computing device, typically having a display screen with touch input and/or a miniature keyboard, and weighing less than 0.91 kilograms (2 pounds)

mobile learning operating system: An information system that provides technical underpinning for educational applications, including standardised interfaces, data persistence and collaboration

mobile learning: See *mLearning*

mobile online course player: An *online course player* that can be installed and run in an optimal way to a mobile device

mobile technology: The technology used for cellular communication. Since the start of this millennium, a standard mobile device has gone from being no more than a simple two-way pager to being a mobile phone, GPS navigation device, an embedded Web browser and instant messaging client, and a hand-held game console.

MobiPocket: An e-book format based on the Open eBook standard using XHTML. It can also include *JavaScript* and frames.

MP3: A popular audio format

MP4: A popular video format

multi-device environment: Physical space that is equipped with interconnected *ICT* devices that provide an integrated information overlay

multiformat format, or multiple formats: An encoded content format for converting a specific type of data to displayable information

native app (or native development): Software developed in the coding language required for one specific mobile device. An example is Objective C (for iOS devices).

NFC (Near Field Communication): A standards-based, short-range wireless connectivity technology that enables convenient short-range communication between electronic devices; used for access control, mobile payments or peer-to-peer data transfer

OAuth: Authentication and Authorisation standard

online course player: A software programme for the delivery of online courses

open source: A philosophy, as well as pragmatic methodology, that promotes free redistribution and access to an end product's design and implementation details

orchestration: In the classroom, refers to the real-time management of and transition between multilayered activities (e.g., individual work, group work and class-level discussions), as well as management of multiple constraints (e.g., time and space constraints, curriculum and assessment requirements, and the energy level of the teacher)

PDA (personal digital assistant): A small, portable mobile device carried by people, often for business (e.g., *smartphone*)

personal computer (PC): Any general-purpose computer whose size, capabilities and original sales price make it useful for individuals, and which is intended to be operated directly by an end-user with no intervening computer operator

podcast: A type of digital media consisting of an episodic series of audio radio, video, PDF or EPUB files subscribed to and downloaded through Web syndication or streamed online to a computer or mobile device

problem-based learning: Learning in which a person develops knowledge by working on tasks and skills authentic to the environment in which those particular skills would be used

QR-code (Quick Response code): A two-dimensional code that enables mobile devices equipped with barcode readers to access additional information by scanning the code

Radio Frequency Identification (RFID): A technology similar in theory to bar code identification. It is used for everything from clothing tags and pet tags to missiles. RFID eliminates the need for line-of-sight reading that bar coding depends on, and can be done at greater distances than bar code scanning.

self-motivational learning: Learning in which a person is able to establish learning goals, increase effort and willingness to continue with learning beyond expectations, and devise more efficient strategies for learning. By adopting a self-regulated approach to learning, the learner gains increased confidence when a goal or task is reached.

sensor: A device for physical or virtual data collection. The sensor information can be used as metadata or as data in ambient information appliances.

sensor network: Network of data collecting ICT systems. A sensor network collects and integrates data from multiple sensing devices. A sensor network relies on pre-configured network connections between.

serious game: A game designed for a primary purpose other than to be purely entertaining

Sharable Content Object Reference Model (SCORM): An eLearning model of the *Advanced Distributed Learning* (ADL) Initiative. It integrates a set of related technical standards, specifications and guidelines designed to meet the SCORM's high-level requirements of creating accessible, interoperable, durable and reusable content and systems. SCORM content can be delivered to learners via any SCORM-compliant *learning management system (LMS)* that uses the same version of the SCORM.

Short Message Service (SMS): A text messaging service component of phone, Web or mobile communication systems, using standardised communications protocols that allow the exchange of short text messages between fixed-line or mobile phone devices

situated cognition: Relates to the idea that learning is best done in a real context of experience, in contrast to knowledge transmission that is given out of context. It has been associated with practical learning experiences such as the apprenticeship model and project-based learning.

smartphone: Mobile phone that includes advanced computing and connectivity functions beyond making phone calls and sending text messages. Smartphones have the capability to display photos, play videos, check and send email, surf the Web, and run third-party applications.

socio-constructivist learning: Learning in which knowledge is co-constructed interdependently between the social setting and the individual

stylus pen: A small pen-shaped instrument used to input commands to a computer screen, mobile device or graphics tablet. With touchscreen devices, a user places a stylus on the surface of the screen to draw, or taps the stylus on the screen to make selections.

synchronisation: The process in which metadata of different entities in *AICHE* applications are matched to filter the most fitting resources for a current context

tablet: A one-piece mobile computer operated primarily by touchscreen. The user's finger functions as the mouse and cursor, removing the need for those

physical hardware components (necessary for a desktop or laptop computer), and the onscreen hideable virtual keyboard is integrated into the display.

transformative learning theory: The theory, first developed by Jack Mezirow in 1978, that dramatic fundamental changes can occur in the way we see ourselves and the world in which we live. The act of transformation in learning involves the individual becoming more critical and reflective in his or her approaches. The individual can learn to be more accepting of new ideas or concepts through the learning process itself.

video stream: Video that is constantly received by and presented to an end-user while being delivered by a provider

virtual education: A form of distance learning in which course content is delivered through the use of various Internet methods and resources, such as course management applications, multimedia and videoconferencing. Students and instructors communicate via these technologies.

virtual learning environment: An education system based on the Web that models conventional real-world education by providing learners with equivalent virtual access to classes, class content, tests, homework, grades, assessments and other external resources (such as academic or museum links). It is also a social space where students and their teacher can interact through threaded discussions or chat. It typically uses Web 2.0 tools for two-way interaction, and includes a content management system.

WebKit: Underpinning software code that powers the mobile browser in Apple (iOS), Android and recent Blackberry devices

Wi-Fi (wireless fidelity): Refers to a set of standards for devices that connect to a local area network using wireless technology

wireless: Means wireless communication, which is the transfer of information between two or more points that are not connected by an electrical conductor. The most common wireless technologies use electromagnetic wireless telecommunications, such as radio.

wisdom of crowds: Term from author James Surowiecki's book of that title (2005, Random House) which explores the idea that decisions made by groups may be better than decisions made by any single members of the group.

PERSPECTIVES ON OPEN AND DISTANCE LEARNING

INCREASING ACCESS THROUGH MOBILE LEARNING

We live today in a hugely “mobilised” world. Estimates put mobile subscriptions at more than 6 billion globally, with at least 75% of these being in developing countries. And nearly 2.5 billion of the world’s population can now access the Internet, a third doing so through mobile devices alone.

As the use of mobile devices increases, so is interest in harnessing their power for education and training. Mobile learning (mLearning) is an emerging field that, with the availability of Open Educational Resources and rapid growth of mobile technologies, has immense potential to revolutionise education — in the classroom, in the workplace, and for informal learning, wherever that may be. With mLearning, education becomes accessible and affordable for everyone.

Many countries have major initiatives underway already to provide mobile technologies to their citizens. These are significant efforts, well aligned with the Commonwealth of Learning’s mandate and UNESCO’s goal of Education for All in the 21st century.

Increasing Access through Mobile Learning contributes to the advancement of the mLearning field by presenting comprehensive, up-to-date information about its current state and emerging potential. This book will help educators and trainers in designing, developing and implementing high-quality mLearning curricula, materials and delivery modes that use the latest mobile applications and technologies. The 16 chapters, written by 30 contributors from around the world, address a wide range of topics, from operational practicalities and best practices to challenges and future opportunities.

Researchers studying the use of mLearning in education and training, including as a means of supporting lifelong learning, will also find the experiences shared in this book to be of particular interest.

PRINTED IN CANADA

Printed according to environmentally progressive print practices, using chlorine-free, recycled fibres. Electricity used in manufacturing the paper stock has been offset by Green-e renewable energy certificates.



MIX
Paper from
responsible sources
FSC® C014956