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

Digital Systems for Open Access to Formal and Informal Learning

Springer

Digital Systems for Open Access to Formal and Informal Learning

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

Digital Systems for Open Access to Formal and Informal Learning

Springer

Editors
Demetrios G. Sampson
Department of Digital Systems,
University of Piraeus
&
Information Technologies Institute (ITI),
Centre for Research and Technology—
Hellas (CERTH)
Greece

Dirk Ifenthaler
Centre for Research in Digital Learning
Deakin University
Melbourne
Australia

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

Pedro Isaías
Universidade Aberta
Lisbon
Portugal

ISBN 978-3-319-02263-5 ISBN 978-3-319-02264-2 (eBook)
DOI 10.1007/978-3-319-02264-2
Springer Cham Heidelberg New York Dordrecht London

Library of Congress Control Number: 2014941451

Printed on acid-free paper

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

Acknowledgements

We acknowledge the support of the International Association for Development of the Information Society (http://www.iadis.org) and for its continuing sponsorship of the *International Conference Cognition and Exploratory Learning in Digital Age* (CELDA). In addition, we express our gratitude to all the members of CELDA2012 international program committee for providing thoughtful reviews for all papers submitted to the conference. Finally, we would like to acknowledge the support provided by Mr. Charalampos Alifragkis, our editorial assistant, who was instrumental in formatting the papers for electronic presentation, and facilitating this edited volume's publication.

Demetrios G. Sampson, Piraeus, Greece
Dirk Ifenthaler, Melbourne, Australia
J. Michael Spector, Denton, TX, USA
Pedro Isaias, Lisbon, Portugal

Contents

1 Digital Systems for Open Access to Formal and Informal Learning 1
Demetrios G. Sampson, Dirk Ifenthaler, Pedro Isaías and J. Michael Spector

Part I Open Access to Formal and Informal Learning: Theory and Practice

2 The Open Discovery Space Portal: A Socially-Powered and Open Federated Infrastructure 11
Athanasiadis Nikolas, Sofoklis Sotiriou, Panagiotis Zervas and Demetrios G. Sampson

3 The Evolution of University Open Courses in Transforming Learning: Experiences from Mainland China 25
Ronghuai Huang, Liang Yu and Junfeng Yang

4 Massive Open Online Courses (MOOCs) and Massively Multiplayer Online Games (MMOGs): Synergies and Lessons to Be Learned 41
Iro Voulgari and Demetrios G. Sampson

5 Supporting Open Access to Teaching and Learning of People with Disabilities 57
Panagiotis Zervas, Vassilis Kardaras, Silvia Baldiris, Jorge Bacca, Cecilia Avila, Yurgos Politis, Deveril, Jutta Treviranus, Ramon Fabregat, Lizbeth Goodman and Demetrios G. Sampson

6 Development of Visualization of Learning Outcomes Using Curriculum Mapping 69
Takashi Ikuta and Yasushi Gotoh

7 Assessing Student Learning Online ... 83
Stephen D. Arnold

8 Theorizing Why in Digital Learning: Opening Frontiers for Inquiry and Innovation with Technology ... 101
Jonathan Charles Mason

Part II Open Access to Formal and Informal Learning: Methods and Technologies

9 Mobile Language Learners as Social Networkers ... 121
Emma Procter-Legg, Annamaria Cacchione, Sobah Abbas Petersen and Marcus Winter

10 A Mobile Location-Based Situated Learning Framework for Supporting Critical Thinking: A Requirements Analysis Study ... 139
Abeer Alnuaim, Praminda Caleb-Solly and Christine Perry

11 Developing Technological and Pedagogical Affordances to Support the Collaborative Process of Inquiry-Based Science Education ... 159
Manoli Pifarré, Rupert Wegerif, Alba Guiral and Mercè del Barrio

12 Learning *in* or *with* Games? ... 181
Jan Hense and Heinz Mandl

13 Digital Game-Based Learning in the Context of School Entrepreneurship Education: Proposing a Framework for Evaluating the Effectiveness of Digital Games ... 195
Hercules Panoutsopoulos and Demetrios G. Sampson

14 Stimulating Learning via Tutoring and Collaborative Simulator Games ... 213
António Alves, Anabela Maria de Sousa Pereira, Hélder Castanheira, Inês Direito and A. Manuel de Oliveira Duarte

15 A Methodology for Organizing Virtual and Remote Laboratories ... 235
Panagiotis Zervas, Alexandros Kalamatianos, Eleftheria Tsourlidaki, Sofoklis Sotiriou and Demetrios G. Sampson

16 Creative Collaboration in a 3D Virtual World: Conducting Educational Activities, Designing Environments, and Preserving Results ... 257
Mikhail Fominykh, Ekaterina Prasolova-Førland and Monica Divitini

17 Active Creation of Digital Games as Learning Tools 275
Alejandro Catala, Fernando Garcia-Sanjuan, Patricia Pons and Javier Jaen

18 Augmented Reality and Learning in Science Museums 293
Susan A. Yoon, Joyce Wang and Karen Elinich

19 From Teachers' to Schools' ICT Competence Profiles 307
Stylianos E. Sergis and Demetrios G. Sampson

20 I^{2}Flex: The Meeting Point of Web-Based Education and Innovative Leadership in a K–12 International School Setting 329
Maria D. Avgerinou, Stefanos Gialamas and Leda Tsoukia

Index 345

Contributors

Abeer Alnuaim King Saud University, Riyadh, Saudi Arabia

António Alves Department of Electronics, Telecommunications and Informatics, University of Aveiro, Aveiro, Portugal

Stephen D. Arnold University of Arizona South, Tucson, AZ, USA

Maria D. Avgerinou American Community Schools Athens, Halandri, Athens, Greece

Cecilia Avila Institute of Informatics and applications, Universitat de Girona, Girona, Spain

Jorge Bacca Institute of Informatics and applications, Universitat de Girona, Girona, Spain

Silvia Baldiris Institute of Informatics and applications, Universitat de Girona, Girona, Spain

Mercè del Barrio Faculty of Education, Universitat de Lleida, Lleida, Spain

Annamaria Cacchione Department of Social Science & Linguistic Centre, University of Molise, Campobasso, Italy

Praminda Caleb-Solly Department of Computer Science and Creative Technologies, University of the West of England, Frenchay Campus, Bristol, UK

Hélder Castanheira Social Services, University of Aveiro, Aveiro, Portugal

Alejandro Catala Grupo ISSI—DSIC, Universitat Politècnica de València, Valencia, Spain

Deveril SMARTlab, School of Education, Roebuck Castle, University College Dublin (UCD), Dublin, Ireland

Inês Direito Department of Education, University of Aveiro, Aveiro, Portugal

Monica Divitini Program for learning with ICT, Norwegian University of Science and Technology, Trondheim, Norway

A. Manuel de Oliveira Duarte Department of Electronics, Telecommunications and Informatics, University of Aveiro, Aveiro, Portugal

Karen Elinich The Franklin Institute, Philadelphia, PA, USA

Ramon Fabregat Institute of Informatics and applications, Universitat de Girona, Girona, Spain

Mikhail Fominykh Program for learning with ICT, Norwegian University of Science and Technology, Trondheim, Norway

Fernando Garcia-Sanjuan Grupo ISSI—DSIC, Universitat Politècnica de València, Valencia, Spain

Stefanos Gialamas American Community Schools Athens, Athens, Greece

Lizbeth Goodman SMARTlab, School of Education, Roebuck Castle, University College Dublin (UCD), Dublin, Ireland

Yasushi Gotoh Niigata University, Niigata, Japan

Alba Guiral Faculty of Education, Universitat de Lleida, Lleida, Spain

Jan Hense Dept. Psychology, Justus-Liebig-Universität Gießen, Gießen, Germany

Ronghuai Huang Faculty of Education, Beijing Normal University, Beijing, P. R. China

Dirk Ifenthaler Centre for Research in Digital Learning, Deakin University, Melbourne, Australia

Takashi Ikuta Niigata University, Niigata, Japan

Pedro Isaías Universidade Aberta, Lisbon, Portugal

Javier Jaen Grupo ISSI—DSIC, Universitat Politècnica de València, Valencia, Spain

Alexandros Kalamatianos Information Technologies Institute, Centre for Research and Technology, Hellas, Thessaloniki, Greece

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

Heinz Mandl Dept. Psychology, Ludwig-Maximilians-Universität München, München, Germany

Jonathan Charles Mason Charles Darwin University, Brinkin, Australia

Athanasiadis Nikolas INTRASOFT International S.A., Luxembourg City, 2b rue Nicolas Bove, Luxembourg City

Hercules Panoutsopoulos Doukas School Greece, Athens, Greece

Anabela Maria de Sousa Pereira Department of Education, University of Aveiro, Aveiro, Portugal

Christine Perry Department of Computer Science and Creative Technologies, University of the West of England, Frenchay Campus, Bristol, UK

Sobah Abbas Petersen SINTEF Technology and Society, Trondheim, Norway

Manoli Pifarré Faculty of Education, Department of Psychology and Pedagogy, Universitat de Lleida, Lleida, Spain

Yurgos Politis SMARTlab, School of Education, Roebuck Castle, University College Dublin (UCD), Dublin, Ireland

Patricia Pons Grupo ISSI—DSIC, Universitat Politècnica de València, Valencia, Spain

Ekaterina Prasolova-Førland Program for learning with ICT, Norwegian University of Science and Technology, Trondheim, Norway

Emma Procter-Legg Bellerbys College Oxford, Oxford, UK

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

Information Technologies Institute, Center for Research and Technology—Hellas, Thessaloniki, Greece

Stylianos E. Sergis Department of Digital Systems, University of Piraeus & Information Technologies Institute, Centre for Research and Technology—Hellas, Thessaloniki, Greece

Sofoklis Sotiriou Ellinogermaniki Agogi, Pallini Attikis, Greece

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

Jutta Treviranus Inclusive Design Research Centre, OCAD University, Toronto, ON, Canada

Raising the Floor International, Geneva, Switzerland

Leda Tsoukia ACS Athens, Athens, Greece

Eleftheria Tsourlidaki Ellinogermaniki Agogi, Pallini, Greece

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

Joyce Wang University of Pennsylvania Graduate School of Education, Philadelphia, PA, USA

Rupert Wegerif Faculty of Education, University of Exeter, Exeter, UK

Marcus Winter University of Brighton, Brighton, UK

Junfeng Yang Education School, Hangzhou Normal University, Hangzhou, Zhejiang Province, P.R. China

Susan A. Yoon University of Pennsylvania Graduate School of Education, Philadelphia, PA, USA

Liang Yu College of Computer and Information Science, Southwest University, Chongqing, P.R. China

Panagiotis Zervas Information Technologies Institute, Centre for Research and Technology Hellas, Thessaloniki, Greece

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

Chapter 1
Digital Systems for Open Access to Formal and Informal Learning

Demetrios G. Sampson, Dirk Ifenthaler, Pedro Isaías and J. Michael Spector

1 Digital Systems for Open Access to Formal and Informal Learning: An Overview

Digital systems and services for technology-supported learning and education, referring to innovative methods, tools/systems and technology-supported services, are recognized as the key drivers to transform the way that individuals, groups and organizations 'learn' and the way to 'assess learning' in the twenty-first century. These transformations influence: objectives—moving from acquiring new 'knowledge' to developing new and relevant 'competences', methods—moving from 'classroom'-based teaching to 'context-aware' personalized learning, and assessment—moving from 'lifelong' degrees and certifications to 'on-demand' and 'in-context' accreditation of qualifications. Within this context, promoting open access

D. G. Sampson (✉)
Department of Digital Systems, University of Piraeus,
150 Androutsou Odyssea Street, GR-18532 Piraeus, Greece
e-mail: sampson@unipi.gr

Information Technologies Institute, Centre for Research and Technology—Hellas,
Thessaloniki, Greece
e-mail: sampson@iti.gr

D. Ifenthaler
Centre for Research in Digital Learning, Deakin University, Burwood VIC 3125, Australia
e-mail: dirk@ifenthaler.info

P. Isaías
Universidade Aberta, Palácio Ceia, Rua da Escola Politécnica, 141–147, 1269–001, Lisbon,
Portugal
e-mail: pisaias@uab.pt

J. M. Spector
Department of Learning Technologies, College of Information, University of North Texas,
3940 N. Elm St., Suite G150, 76207, Denton, TX, USA
e-mail: mike.spector@unt.edu

D. G. Sampson et al. (eds.), *Digital Systems for Open Access to Formal and Informal Learning,*
DOI 10.1007/978-3-319-02264-2_1,

to formal and informal learning is currently a key issue in the public discourse and global dialogue on education.

These developments have led to new research challenges which are discussed in this volume. This book under the general title Digital Systems for Open Access to Formal and Informal Learning captures current state of the art in both Theory and Practice (Part I) and Methods and Technologies (Part II). The volume consists of 20 chapters selected from among peer-reviewed papers presented at the CELDA (Cognition and Exploratory Learning in the Digital Age) 2012 conference as well as scholars from around the world who were invited to contribute in particular topics of this book.

Chapter 2 entitled '*The Open Discovery Space Portal: a Socially Powered and Open Federated Infrastructure*' by Nikolas Athanasiadis, Sofoklis Sotiriou, Panagiotis Zervas and Demetrios G. Sampson (Athanasiadis et al. 2014) reports on the development of a prominent European initiative namely the Open Discovery Space (ODS) portal. ODS aims to (a) build a federated infrastructure for a super-repository on top of existing learning object repositories (LORs) and federated infrastructures and (b) provide social features for building and sustaining web-based educational communities and communities of best teaching practices from 2,000 European schools. To this end, Chap. 2 presents the architecture of the ODS portal as well as its current implementation and future plans.

Chapter 3 entitled '*The Evolution of University Open Courses in Transforming Learning: Experiences from Mainland China*' by Ronghuai Huang, Liang Yu and Junfeng Yang (Huang et al. 2014) reports on the trends for the development of university open courses in mainland China. The authors review the history of university open courses and identify three stages of open course development. Then, they introduce and analyse the major projects in each stage for its strength and weakness; especially the experiences on open courses from mainland China are analysed from their background, implementation and impacts. Finally, the authors propose a framework for speculating open courses and analyse the strategies for the development of university courses based on this framework.

Chapter 4 entitled '*Massive Open Online Courses (MOOCs) and Massive Multiplayer Online Games (MMOGs): Synergies and Lessons to be Learnt*' by Iro Voulgari and Demetrios G. Sampson (Voulgari and Sampson 2014) discusses possible synergies between massively multiplayer online games (MMOGs) and massive open online courses (MOOCs) and lessons to be learnt from these synergies. The authors take the standpoint that MOOCs are facing the challenge of designing learner-centred online courses for the masses, rather than just provide open access to static educational resources. As a result, the authors stress that MOOCs' design involves, among others, the pedagogically meaningful and effective handling of massive numbers of people and massive volumes of educational resources. To this end, the authors discuss whether and how existing research from the educational exploitation of MMOGs can provide valuable insights on issues such as engagement, commitment, learner connectedness and the distributed resources.

Chapter 5 entitled '*Supporting Open Access to Teaching and Learning of People with Disabilities*' by Panagiotis Zervas, Vassilis Kardaras, Silvia Baldiris, Jorge

Bacca, Cecilia Avila, Yurgos Politis, Deveril, Jutta Treviranus, Ramon Fabregat, Lizbeth Goodman and Demetrios G. Sampson (Zervas et al. 2014) presents an online educational portal, namely the Inclusive Learning Portal, which aims to support open access to teaching and learning of people with disabilities. More specifically, the Inclusive Learning Portal architecture is presented, which contains a repository of accessible learning objects (LOs), complementary services that enable easy development and delivery of accessible LOs, as well as teacher training opportunities in the use of these services.

Chapter 6 entitled '*Development of Visualization of Learning Outcomes Using Curriculum Mapping*', by Takashi Ikuta and Yasushi Gotoh (Ikuta and Gotoh 2014), presents a study that examines whether visualized learning outcomes provide an overall picture of graduate attributes and skills by looking at students and teaching bodies involved in educational programmes based on Niigata University Bachelor Assessment System (NBAS). This chapter contributes to the open access to learners' data analysis within formal educational systems, namely, in this case at higher education.

Chapter 7 entitled '*Assessing Student Learning Online*' by Stephen D. Arnold (Arnold 2014) discusses the issue of assessing students learning in massive online university courses. The author reports on ways to strengthen student learning assessment reliability in online courses using alternative digital pontifications. This chapter contributes to the discussion on student learning assessment in MOOCs.

Chapter 8 entitled '*Theorizing Why in Digital Learning*' by Jon Mason (Mason 2014) reports on findings from relevant research and practice with a view to informing the design of digital tools that might stimulate deep learning and cognitive engagement in open formal and informal educational setting. The author discusses the distinction between sense-making and meaning-making, an important construct in the literature associated with constructivism and 'meaning-centred education' with direct implications for the design of MOOCs.

Chapter 9 entitled '*Mobile Language Learners as Social Networkers*' by Emma Procter-Legg, Annamaria Cacchione, Sobah Abbas Petersen and Marcus Winter (Procter-Legg et al. 2014) identifies language learners as social networkers and discusses their attitudes by analysing the content created by them using a situated mobile language learning app, namely LingoBee, based on the idea of crowd sourcing. Borrowing ideas from other studies conducted on social network users, the authors consider language learners using LingoBee as a social network who behave as social networkers by creating content, acting as conversationalists, critics and displaying other behaviours shown by social networkers. In addition to this, from their user studies, the authors claim that language learners are stimulated by the contributions of other learners as well as welcoming competition among learners.

Chapter 10 entitled '*A Mobile Location-Based Situated Learning Framework for Supporting Critical Thinking—A Requirements Analysis Study*' by Abeer Alnuaim, Praminda Caleb-Solly and Christine Perry (Alnuaim et al. 2014) presents the requirements work carried out as part of developing an intervention to improve students' analysis and critical thinking skills using location-based mobile learning. As part of this study, the authors identified weaknesses in the current teaching modes to determine the type and nature of location-based hints and formative feedback that their system can provide to support students' understanding of the context they are in.

Chapter 11 entitled '*Developing Technological and Pedagogical Affordances to Support Collaborative Inquiry Science Processes*' by Manoli Pifarré, Rupert Wegerif, Alba Guiral and Mercè del Barrio (Pifarré et al. 2014) presents the design, implementation and evaluation of the web-based learning environment referred to as Metafora (Learning to learn together: A visual language for social orchestration of educational activities) which provides a planning and reflection tool using a visual language representing the key components and features required for learning how to learn together (L2L2), in the context of solving a complex science problem.

Chapter 12 entitled '*Learning in or with Games?*' by Jan Hense and Heinz Mandl (Hense and Mandl 2014) aims to systematically analyse the theoretical underpinnings of learning with digital games and subsequently deduce criteria and guidelines for the design and application of effective digital learning games (DLGs) from this theoretical analysis. The authors conclude with an outlook on possible applications and further challenges for the theoretical foundation of learning with and in digital learning games and a discussion of the role of open access in regard to DLGs.

Chapter 13 entitled '*Digital Game-Based Learning in the Context of School Entrepreneurship Education: Proposing a Framework for Evaluating the Effectiveness of Digital Games*' by Hercules Panoutsopoulos and Demetrios G. Sampson (Panoutsopoulos and Sampson 2014) analytically describes the role that digital games can play as tools capable of enhancing entrepreneurship education (with a specific focus on school entrepreneurship education and its particularities) and proposes a framework for evaluating the effectiveness of digital games in this domain of application.

Chapter 14 entitled '*Stimulating Learning via Tutoring and Collaborative Simulator Games*' by António Alves, Anabela Maria de Sousa Pereira, Hélder Castanheira, Inês Direito and A. Manuel de Oliveira Duarte (Alves et al. 2014) presents two initiatives developed in University of Aveiro aiming to enhance student learning. More specifically, the authors present (a) a tutoring system to support undergraduate students learning in science, technology, engineering and mathematics (STEM) subjects and tools and (b) a simulator game to support telecommunications engineering students learning and entrepreneurship.

Chapter 15 entitled '*A Methodology for Organizing Virtual and Remote Labs*' by Panagiotis Zervas, Alexandros Kalamatianos, Eleftheria Tsourlidaki, Sofoklis Sotiriou and Demetrios G. Sampson (Zervas et al. 2014) discusses the open access to virtual and remote laboratory for science school education. More specifically, the authors take stock of the current landscape of available repositories of virtual and remote laboratories and identify common metadata elements, propose a methodology for organizing virtual and remote laboratories by exploiting common metadata elements from existing repositories and introduce the concept of big ideas of science, as a complementary way of organizing virtual and remote laboratories based on fundamental ideas of the real world.

Chapter 16 entitled '*Creative Collaboration in a 3D Virtual World*' by Mikhail Fominykh, Ekaterina Prasolova-Førland and Monica Divitini (Fominykh et al. 2014) presents authors' experience from conducting the Virtual Summer School in Second Life as an attempt to provide a systematized support for creative communities in a multi-cultural, cross-disciplinary context. In this way, a virtual summer school could be thought of as a framework or a technique that provides support for community building, collaborative creativity and idea dissemination. Based on the data collected during the summer school and the follow-up events, the authors identified implications for conducting creative activities, supporting these activities by the features of the 3D environment, and retrieving the knowledge from them.

Chapter 17 entitled '*Active Creation of Digital Games as Learning Tools*' by Alejandro Catalá, Fernando Garcia-Sanjuan, Patricia Pons and Javier Jaén (Catalá et al. 2014) reviews a number of outstanding efforts on providing advanced systems for the creation of digital games or simulations by children or young users and analyses their characteristics in terms of technology and the creation degree offered in both authorship and play processes.

Chapter 18 entitled '*Augmented Reality and Learning in Science Museums*' by Susan A. Yoon, Joyce Wang and Karen Elinich (Yoon et al. 2014) presents authors' findings from their project ARIEL—Augmented Reality for Interpretive and Experiential Learning, a 3-year project that has piloted and investigated the impact of a field-tested, exportable and replicable system for the overlay of augmented reality interfaces onto fixed-position science museum exhibit devices. The project has created an open-source exhibit platform that uses digital scientific visualization to transform visitor interaction with traditional hands-on exhibits by merging the experiential and interpretive aspects of the encounter.

Chapter 19 entitled '*From Teachers' to Schools' ICT Competence Profiles*' by Stelios Sergis and Demetrios G. Sampson (Sergis and Sampson 2014) presents a proposal for a unified school information and communication technology (ICT) competence profiling framework. More specifically, the authors offer an overview of the concept of individual and organizational competence and discuss the concept of eMaturity, which is the current approach towards measuring ICT integration in educational institutions. Then, based on this critical discussion, the authors identify whether this approach, and the frameworks that implement it, accommodate the full spectrum of the important elements affecting ICT uptake in schools, as defined by the organizational competence analysis, and propose improvements that would remedy for any identified gap.

Chapter 20 entitled '*I^2Flex: The Meeting Point of Web-Based Education and Innovative Leadership in a K-12 International School Setting*' by Maria Avgerinou, Stefanos Gialamas and Leda Tsoukia (Avgerinou et al. 2014) presents and discusses the American Community School of Athens (ACS Athens), Greece, education paradigm named Morfosis, which is defined within the twenty-first-century framework as a holistic, meaningful and harmonious educational experience, guided by ethos. Then, the authors outline manifestations in praxis of the i2Flex (isquareFlex), a non-traditional learning methodology, organically developed by the ACS Athens community of learners and offer a set of recommendations as to its effective implementation in diverse K–12 settings.

References

Alnuaim, A., Caleb-Solly, P., & Perry, C. (2014). A mobile location-based situated learning framework for supporting critical thinking—a requirements analysis study. In D. Sampson, D. Ifenthaler, P. Isaías, & J. M. Spector (Eds.), *Digital systems for open access to formal and informal learning*. New York: Springer.

Alves, A., Pereira, A. M. S., Custanheira, H., Direito, I., & Duarte, A. M. O. (2014). Stimulating learning via tutoring and collaborative simulator games. In D. Sampson, D. Ifenthaler, P. Isaías, & J. M. Spector (Eds.), *Digital systems for open access to formal and informal learning*. New York: Springer.

Arnold, S. D. (2014). Assessing student learning online. In D. Sampson, D. Ifenthaler, P. Isaías, & J. M. Spector (Eds.), *Digital systems for open access to formal and informal learning*. New York: Springer.

Athanasiadis, N., Sotiriou, S., Zervas, P., & Sampson, D. (2014). The open discovery space portal: A socially-powered and open federated infrastructure. In D. Sampson, D. Ifenthaler, P. Isaías, & J. M. Spector (Eds.), *Digital systems for open access to formal and informal learning*. New York: Springer.

Avgerinou, M. D., Gialamas, S., & Tsoukia, L. (2014). I2Flex: The meeting point of web-based education and innovative leadership in A K-12 international school setting. In D. Sampson, D. Ifenthaler, P. Isaías, & J. M. Spector (Eds.), *Digital systems for open access to formal and informal learning*. New York: Springer.

Catalá, A., Garcia-Sanjuan, F., Pons, P., & Jaén, J. (2014). Active creation of digital games as learning tools. In D. Sampson, D. Ifenthaler, P. Isaías, & J. M. Spector (Eds.), *Digital systems for open access to formal and informal learning*. New York: Springer.

Fominykh, M., Prasolova-Førland, E., & Divitini, M. (2014). Creative collaboration in a 3D virtual world. In D. Sampson, D. Ifenthaler, P. Isaías, & J. M. Spector (Eds.), *Digital systems for open access to formal and informal learning*. New York: Springer.

Hense, J., & Mandl, H. (2014). Learning in or with games? In D. Sampson, D. Ifenthaler, P. Isaías, & J. M. Spector (Eds.), *Digital systems for open access to formal and informal learning*. New York: Springer.

Huang, R., Yu, L., & Yang, J. (2014). The evolution of university open courses in transforming learning: Experiences from mainland China. In D. Sampson, D. Ifenthaler, P. Isaías, & J. M. Spector (Eds.), *Digital systems for open access to formal and informal learning*. New York: Springer.

Ikuta, T., & Gotoh, Y. (2014). Development of visualization of learning outcomes using curriculum mapping. In D. Sampson, D. Ifenthaler, P. Isaías, & J. M. Spector (Eds.), *Digital systems for open access to formal and informal learning*. New York: Springer.

Mason, J. (2014). Theorizing why in digital learning. In D. Sampson, D. Ifenthaler, P. Isaías, & J. M. Spector (Eds.), *Digital systems for open access to formal and informal learning*. New York: Springer.

Panoutsopoulos, H., & Sampson, D. (2014). Digital game-based learning in the context of school entrepreneurship education: Proposing a framework for evaluating the effectiveness of digital games. In D. Sampson, D. Ifenthaler, P. Isaías, & J. M. Spector (Eds.), *Digital systems for open access to formal and informal learning*. New York: Springer.

Pifarré, M., Wegerif, R., Guiral, A., & del Bario, M. (2014). Developing technological and pedagogical affordances to support collaborative inquiry science processes. In D. Sampson, D. Ifenthaler, P. Isaías, & J. M. Spector (Eds.), *Digital systems for open access to formal and informal learning*. New York: Springer.

Procter-Legg, E., Cacchione, A., Petersen, S. A., & Winter, M. (2014). Mobile language learners as social networkers. In D. Sampson, D. Ifenthaler, P. Isaías, & J. M. Spector (Eds.), *Digital systems for open access to formal and informal learning*. New York: Springer.

Sampson, D., Ifenthaler, D., Isaías, P., & Spector, J. M. (Eds.). (2014). *Digital systems for open access to formal and informal learning*. New York: Springer.

Sergis, S., & Sampson, D. (2014). From teachers 'to schools' ICT competence profiles. In D. Sampson, D. Ifenthaler, P. Isaías, & J. M. Spector (Eds.), *Digital systems for open access to formal and informal learning*. New York: Springer.

Voulgari, I., & Sampson, D. (2014). Massive open online courses (MOOCs) and massive multi-player online games (MMOGs): Synergies and lessons to be learnt. In D. Sampson, D. Ifenthaler, P. Isaías, & J. M. Spector (Eds.), *Digital systems for open access to formal and informal learning*. New York: Springer.

Yoon, S. A., Wang, J., & Elinich, K. (2014). Augmented reality and learning in science museums. In D. Sampson, D. Ifenthaler, P. Isaías, & J. M. Spector (Eds.), *Digital systems for open access to formal and informal learning*. New York: Springer.

Zervas, P., Kalamatianos, A., Tsourlidaki, E., Sotiriou, S., & Sampson, D. (2014). A methodology for organizing virtual and remote labs. In D. Sampson, D. Ifenthaler, P. Isaías, & J. M. Spector (Eds.), *Digital systems for open access to formal and informal learning*. New York: Springer.

Zervas, P., Kardaras, V., Baldiris, S., Bacca, J., Avila, C., Politis, Y., Deveril, Treviranus, J., Fabregat, R., Goodman, L., & Sampson, D. (2014). Supporting open access to teaching and learning of people with disabilities. In D. Sampson, D. Ifenthaler, P. Isaías, & J. M. Spector (Eds.), *Digital systems for open access to formal and informal learning*. New York: Springer.

Part I
Open Access to Formal and Informal Learning: Theory and Practice

Chapter 2
The Open Discovery Space Portal: A Socially-Powered and Open Federated Infrastructure

Athanasiadis Nikolas, Sofoklis Sotiriou, Panagiotis Zervas and Demetrios G. Sampson

1 Introduction

Over the past years, the term open educational resources (OERs) has emerged, aiming to promote open access to digital educational resources, in the form of learning objects (LOs) that are openly licensed and available online for everyone to use (Caswell et al. 2008). UNESCO (2002) has defined OERs as the "technology-enabled, open provision of educational resources for consultation, use and adaptation by a community of users for non-commercial purposes".

The expected benefits of OERs for learners and teachers can be summarized as follows (Geser 2007): (a) They are free to use and publicly available, (b) they can be used and/or reused in teaching and learning (usually with attribution to the creator), (c) they can be repurposed, that is, modified/adapted for different educational

A. Nikolas (✉)
INTRASOFT International S.A., 2b rue Nicolas Bove, 1253 Luxembourg City
e-mail: Nikolas.Athanasiadis@intrasoft-intl.com

S. Sotiriou
Ellinogermaniki Agogi, Dimitriou Panagea Str. 153 51 Pallini Attikis, Greece
e-mail: sotiriou@ea.gr

P. Zervas
Department of Digital Systems, University of Piraeus,
150 Androutsou Odyssea Street, GR-18532 Piraeus, Greece
e-mail: pzervas@iti.gr

Information Technologies Institute, Centre for Research
and Technology—Hellas, Thessaloniki, Greece

D. G. Sampson
Department of Digital Systems, University of Piraeus,150 Androutsou Odyssea Street,
GR-18532 Piraeus, Greece
e-mail: sampson@unipi.gr

Information Technologies Institute, Centre for Research and Technology—Hellas,
Thessaloniki, Greece
e-mail: sampson@iti.gr

D. G. Sampson et al. (eds.), *Digital Systems for Open Access to Formal and Informal Learning*,
DOI 10.1007/978-3-319-02264-2_2,

context of use, (d) they can improve teaching by building on other people's work and (e) their development is a global movement and as a result educational communities across borders can be created around them.

In response to this emerging term, several OER initiatives have been developed worldwide by large institutions such as MIT's OpenCourseWare (OCW), Stanford‘s iTunes and Rice University‘s Connexions, or by communities (or consortiums) such as MERLOT and OER Commons (Ehlers 2011; Walsh 2010). The main aim of such initiatives is to support the process of organizing, classifying and storing LOs and their associated metadata in web-based repositories which are called learning object repositories (LORs; McGreal 2008). As a result, a variety of LORs are currently operating online, facilitating end users (namely, students and teachers) to have access to numerous collections of LOs (Ehlers 2011)

However, with many LORs implemented and maintained independently, valuable LOs are scattered over different LORs and it might be difficult for end users to easily access them (Klerkx et al. 2010). A suggested solution towards addressing this issue is to create infrastructures that enable the discovery and identification of LOs across different LORs. As a result, several federated infrastructures have been developed and are currently operating online such as ARIADNE (Ternier et al. 2009), Metadata for Architectural Contents in Europe (MACE; Prause et al. 2007), Interoperable Content for Performance in a Competency-driven Society (iCOPER; Totschnig 2007), Organic.Edunet (Manouselis et al. 2009), OpenScout (Kalz et al. 2010) and Learning Resource Exchange (Massart 2009)

Within this context, a prominent European initiative has been launched, namely the Open Discovery Space (ODS) portal, which aims to (a) build a federated infrastructure for a super-repository on top of existing LORs and federated infrastructures and (b) provide social features for building and sustaining web-based educational communities and communities of best teaching practices from 2,000 European schools. To this end, the aim of this book chapter is to present the architecture of the ODS portal, as well as its current implementation and future plans.

The book chapter is structured as follows. Following this introduction, Sect. 2.2 describes the requirements of the ODS portal, based on which we compare existing federated infrastructures in Sect. 2.3. Afterwards, Sect. 2.4 presents the conceptual architecture of the ODS infrastructure and its main components, while Sect. 2.5 presents the implementation of the ODS portal. Finally, we discuss our main conclusions and ideas for further work.

2 Requirements of the ODS Portal

This section focuses on the first step of the development life cycle (Avison and Shah 1997), namely requirements analysis, by first setting a common terminology, identifying the main portal users and afterwards discussing functional and non-functional requirements.

2.1 Terminology

The ODS portal aims to include LOs organized in three aggregation levels as follows:

- *Educational resources* are typically digital materials such as video and audio lectures (podcasts), references and readings, workbooks and textbooks, multimedia animations, simulations and demonstrations.
- *Lesson plans* provide teachers with guidelines for conducting a lesson, and contain information about the students, the educational resources and tools that should be used, the educational objectives, the teaching method to be used, as well as the assessment method. Lesson plans can be (re)used by the same teacher, as well as by other teachers.
- *Educational scenarios* follow the same structure as the lesson plans but are of more extended duration. Educational scenarios either can be performed inside the formal classroom or can be combined with non-formal settings such as museums and field trips.

2.2 Users

We identify two main types of portal users as follows:

- *Teachers*: They are the main recipient of the functionality offered by the ODS portal. They are able to create an account, which allows them to access personalized services based on their profile. Teachers are able to search for LOs, as well as create and upload their own LOs. Moreover, they can build communities and formulate groups of interest. Finally, they can engage in full social network interactions, such as participation in activities, events, polls, discussions and blogs.
- *Parents*: They use the ODS portal, in order to interact with the teachers of their children. More precisely, parents can create an account, which allows them to join teachers' communities, groups, activities or events, so as to communicate with teachers.

2.3 Functional Requirements

In this section, we present the main functionalities that are required by the ODS portal users to address their needs. These functionalities can be summarized as below:

- *User profiling*: Users should be able to create their profile and access a dashboard with the activities that they have performed in the ODS portal.
- *Uploading LOs*: Users should be able to upload and store LOs to the ODS portal by describing them with appropriate educational metadata.

- *Authoring LOs*: Users should be able to use authoring tools for developing LOs in the form of lesson plans and educational scenarios.
- *Annotating LOs*: Users should be able to rate, comment, tag and bookmark LOs. These annotations are expected to be used by other users for assessing the quality of the LOs during searching.
- *Searching LOs*: Users should be able to search for LOs across existing repositories by using formal metadata added by the authors of the LOs, e.g. grade level, subject domain, etc., as well as by using social metadata added by the users of the LOs such as social tags and ratings.
- *Recommending LOs and Users*: Users should be able to receive recommendations for LOs based on their preferences, as well as recommendations for users to connect and communicate.
- *Managing communities*: Users should be able to organize their own lightweight portals, by creating open and/or private communities at international, national or thematic levels, to create and share their LOs.
- *Communicating with users*: Users should have proper tools available for communicating with other users in order to create their own networks into the lightweight portals, to share and discuss LOs, events and news of their interest and to have direct communication with their connections.
- *Participating to in training academies*: Users should have access to training academies that offer them training opportunities towards enhancing their competences about using information and communications technology (ICT) in education.

2.4 Non-Functional Requirements

Next to the previous requirements, there are also non-functional requirements that can influence the design of the ODS portal as follows:

- *Scalability*: The ODS portal is expected to involve 2,000 schools around Europe. Therefore, it is clear that the underling network, hardware and software infrastructure should have sufficient capacity and employ appropriate techniques such as load balancing.
- *Internationalization*: The ODS portal should be available in 17 EU languages, so as to overcome the language barrier and involve smoothly the anticipated number of 2,000 schools.
- *API*: The ODS portal should be extensible and allow for the reuse of the LOs metadata it harvests and stores. A search API will be provided in order for third parties to utilize the ODS infrastructure.
- *Usability*: The ODS portal should deliver various tools (such as metadata-authoring and scenario-authoring tools) which should be intuitive and easy to use in order to reduce the workload of users and keep them involved.
- *Privacy*: The ODS portal will store users' personal information. Therefore, the portal should protect any personal or private information belonging to the user.

- *Spam filters*: In a social environment with high volume of communication, there will be users who will attempt to exploit the community to send messages unrelated to the purpose of the portal. The ODS portal should employ spam filters to allow users to control and block unwanted messages and report abuse.

3 Related Work

In this section, we provide an overview of existing federated infrastructures and we compare their features with the functional requirements presented in Sect. 2.2.2. We have identified six existing federated infrastructures, namely: (a) the ARIADNE Finder,[1] developed by the ARIADNE Foundation, (b) the MACE portal[2] that was developed in the framework of an EU-funded project, referred to as "Metadata for Architectural Contents in Europe", (c) the iCOPER portal,[3] developed in the framework of an EU-funded best practice network, referred to as "Interoperable Content for Performance in a Competency-Driven Society," (d) the OpenScout[4] portal, developed in the framework of an EU-funded project, referred to as "Skill-based scouting of open user-generated and community-improved content for management education and training," (e) the Organic.Edunet Portal,[5] developed in the framework of an EU-funded project, referred to as "A Multilingual Federation of Learning Repositories with Quality Content for the Awareness and Education of European Youth about Organic Agriculture and Agroecology" and (f) the European Schoolnet's LRE Portal.[6] Table 2.1 summarizes these federated infrastructures.

As we can notice from Table 2.1, the main requirements that are supported by existing federated infrastructures are: user profiling, annotating LOs, searching LOs and communicating with users. On the other hand, there are several requirements that are not supported or partially supported by existing federated infrastructures such as: uploading LOs, authoring LOs, recommending LOs and users, managing communities and participating in training academies. As a result, it is evident that ODS portal aims to advance existing solutions and offer an enhanced federated infrastructure.

[1] http://ariadne.cs.kuleuven.be/finder/ariadne/.

[2] http://portal.mace-project.eu/.

[3] http://www.icoper.org/open-content-space.

[4] http://www.openscout.net/.

[5] http://organic-edunet.eu/.

[6] http://lreforschools.eun.org.

Table 2.1 Comparing existing federated infrastructures with ODS portal's functional requirements

Functional requirements	Ariadne	MACE	iCOPER	OpenScout	Organic. Edunet	LRE
User profiling	×	✓	✓	✓	✓	✓
Uploading LOs	×	✓	×	✓	×	×
Authoring LOs	×	×	✓	✓	×	×
Annotating LOs	×	✓	✓	✓	✓	✓
Searching LOs	✓	✓	✓	✓	✓	✓
Recommending LOs and users	×	×	×	~	×	~
Managing communities	×	×	×	~	×	×
Communicating with users	×	✓	✓	✓	×	✓
Participating in training academies	×	×	~	×	×	×

Legend: requirement supported (✓), partially supported (~), not supported (×)

4 The ODS Portal Architecture

This section presents the ODS portal architecture that has been designed based on the functional requirements defined in Sect. 2.2.

4.1 Overview

The overall architecture of the ODS portal is presented in Fig. 2.1. As we can notice, at the lower level there are existing repositories. The metadata of these repositories are harvested and stored in the ODS repository, which is located in the middle level of the architecture. Moreover, in the middle level of the architecture there are two types of metadata harvesters, namely: (a) educational metadata harvester, which aims to harvest metadata that have been created by the authors of the LOs and they are stored in the external repositories and (b) social data harvester, which aims to harvest social data that are also stored in the external repositories. Social data consist of (Bienkowski et al. 2012): (a) social tags and evaluative metadata, which are user-generated data derived by the interaction of the users with an LO (e.g. comments, rating, tagging) and (b) paradata, which are system-generated data and indicate the usage of an LO within an appropriate context (e.g. how many users have used, share or bookmarked an LO)

Finally, in the upper level of the architecture there is the ODS portal interface which includes (a) a searching mechanism for accessing the ODS repository, (b) the community pages, which are created by the teachers and they are using and storing LOs from/to the ODS repository, (c) authoring tools for metadata and educational scenario authoring and (d) a recommender system for recommending suitable LOs and appropriate users for communication.

The next section elaborates on the components of the architecture in more detail.

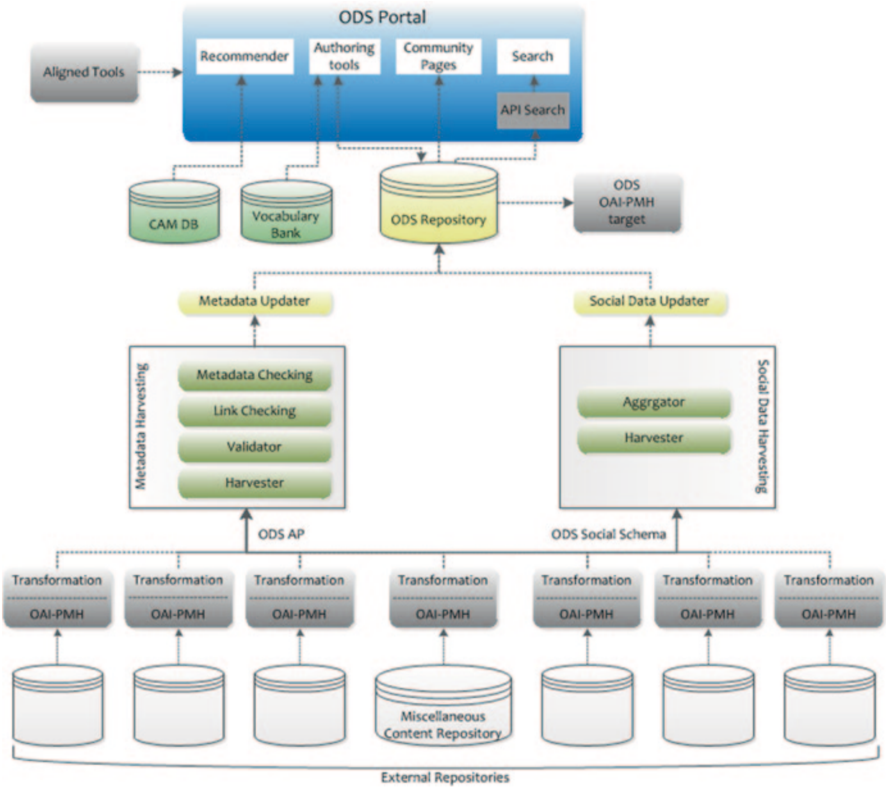


Fig. 2.1 ODS portal architecture

4.2 Components

External Repositories include LORs that have been developed in the framework of previous EU-funded or national-funded projects and the ODS portal aims to federate them. Moreover, this component includes repositories with miscellaneous resources (not only related to school education) such as cultural heritage resources, video archives, etc.

Metadata Harvester collects educational metadata from the external repositories. It includes four subcomponents, which are the following:

- *Harvester*: It harvests metadata records provided by external repositories. In order to ensure interoperability of the harvesting process, the harvester has been based on open standards such as the Open Archives Initiative Protocol for Metadata Harvesting (OAI-PMH). Moreover, all metadata records from external repositories are transformed to ODS metadata application profile (ODS AP). ODS AP is based on the IEEE Learning Object Metadata (IEEE LOM) standard (IEEE

LTSC 2005) and it has been tailored specifically to support the classification of LOs based on their learning context of use, that is, the pedagogical approach adopted, the subject domain, the intended educational objectives and the environment within which the LOs are used. ODS AP is used to describe all LOs made available through the ODS portal. Apart from ensuring a unified way of describing LOs, it serves as basis for enriching incomplete metadata.
- *Validator*: It validates the metadata records that are harvested by the harvester, so as to ensure that they conform to the ODS AP.
- *Link checking*: It is used in order to verify that the metadata record includes a valid URL to the respective LO of the external repository. If the URL doesn't work then the metadata record is excluded from the harvesting process.
- *Metadata checking*: It performs a completeness check of the metadata records that are harvested based on the ODS AP. If there are metadata records that are incomplete, they are flagged, so to be enriched in the future by appropriate ODS portal users.

Social data Harvester collects social data from the external repositories. It includes two subcomponents, which are the following:

- *Harvester*: It harvests social data provided by external repositories. This subcomponent also uses the OAI-PMH, so as to ensure interoperability of the harvesting process. Moreover, all social data from external repositories are transformed to the ODS social schema, which is used to describe in a machine-readable way the social data of the ODS portal.
- *Aggregator*: It aggregates the social data that are harvested by the external repositories, in order to transfer them to the upper layer.

The ODS Repository aggregates the metadata and the social data of the LOs that are produced from the ODS portal and harvested from external repositories.

The ODS Portal is the interface that is presented to the portal's users. It includes four main subcomponents, namely:

- *Search*: It facilitates users to search for LOs by following different approaches such as: (a) *Simple keyword search*: Using keywords and combinations, the user is able to search through the LOs within the ODS portal. The keyword search uses the metadata that describes the LOs, taking into account metadata provided by external repositories as well as social tags provided by users. (b) *Browse by classification*: Many of the LOs included within the ODS portal are classified using vocabularies and taxonomies for different metadata elements of the ODS AP. The user is able to browse LOs by clicking on the terms of these vocabularies and taxonomies. (c) *Facetted search*: The user is able to qualify the keyword search with several additional facets such as the external repositories in which to search, the language of the results, the LO type, etc. When a value is selected for a facet, the interface dynamically changes and provides the numbers of results for each facet that match the selected criteria. (d) *Social tagging search*: The user is presented with the most popular tags contributed by ODS portal's users, visualized by a tag cloud. A tag links to the respective LO(s). (e) *Personalized search*: The users are presented with search results that are ranked based on their competence profile. This requires that the users have previously completed their competence profile, which is based on the UNESCO ICT Competency Framework for Teachers (UNESCO 2011).

- *Community pages*: It enables users to easily set-up and deploy their own lightweight portal versions (named MyDiscoverySpace) that will fit to their community needs (e.g. thematic or linguistic). The MyDiscoverySpace sites have their own repositories and their members are able to create and share LOs with other members of these sites.
- *Authoring tools*: This subcomponent enables users to create and upload their LOs to the ODS portal. The subcomponent includes a metadata authoring tool for adding educational metadata following the ODS AP and an educational scenario authoring tool that facilitates users to create their own lesson plans and educational scenarios. Both tools are communicating with a vocabulary bank where all vocabularies and taxonomies of the ODS AP are stored for easiest management and maintenance. These tools are also used by the ODS portal users to edit and enrich the LOs that are harvested by the external repositories, creating new versions of these LOs and redefining them in different educational contexts of use.
- *Recommendation system*: The purpose of this component is to predict the user preferences on items such as LOs and user connections, so as to recommend appropriate LOs and users for connect and communicate. The recommendation system stores its data by following the Contextualized Attention Metadata (CAM), which is a format to describe events conducted by a human user (Schmitz et al. 2012).

Aligned Tools include tools for LOs' authoring and publishing that have been developed in the framework of other EU-funded or national-funded projects and the ODS portal aims to align them so that they can expose ODS AP-compliant metadata, so as to be directly harvested by the ODS portal.

5 Implementation of the Ods Portal

Based on the presented design, the ODS portal[7] has been developed following an iterative and incremental approach. The home page of the ODS portal, at the time of writing,[8] is presented in Fig. 2.2.

An important element of the ODS portal architecture is the ODS AP. The ODS AP has been implemented in accordance with the steps of the guidelines proposed by international organizations such as IMS Global Learning Consortium (IMS

[7] http://portal.opendiscoveryspace.eu/.

[8] November 2013.

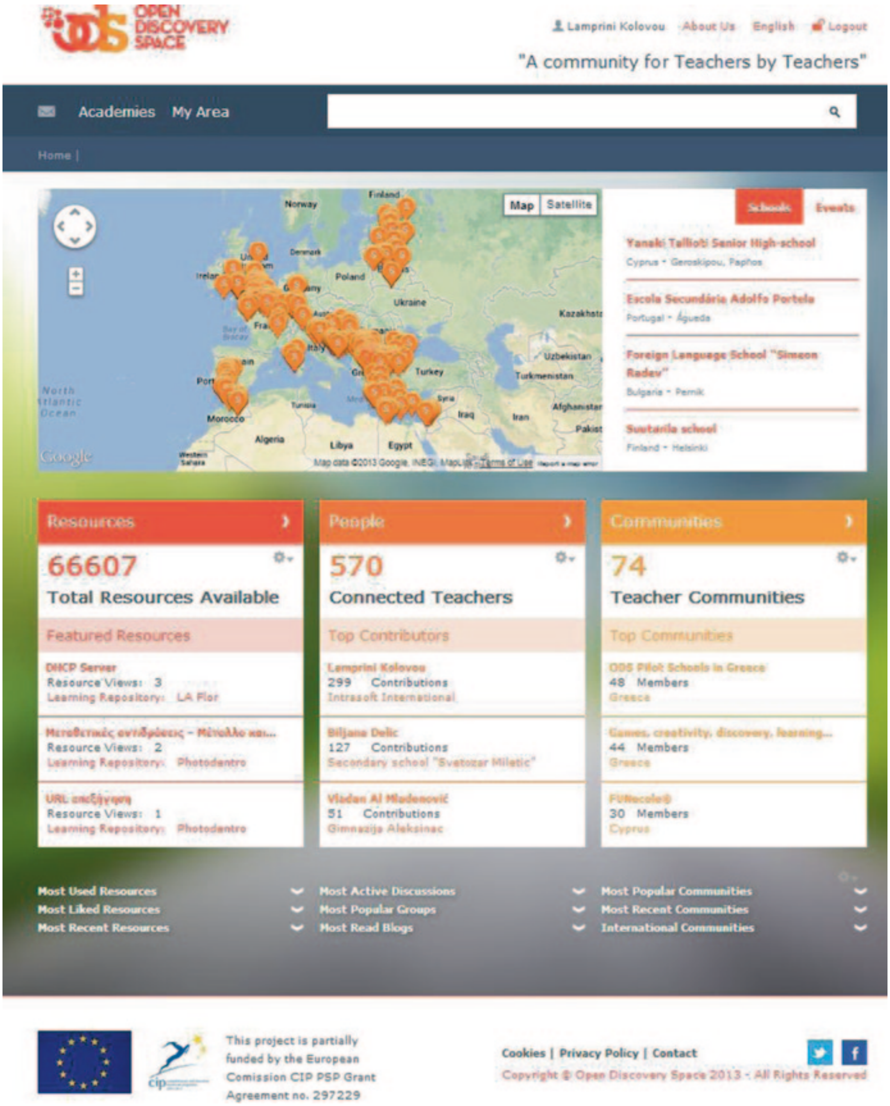


Fig. 2.2 The ODS portal home page

GLC) and European Committee for Standardization (CEN/ISSS) for developing IEEE LOM APs (Duval et al. 2006; IMS GLC 2005). The ODS AP consists of 2 mandatory elements, 18 recommended elements and 25 optional elements. ODS LOM AP's mandatory elements derive from the general and technical category of the IEEE LOM standard, whereas the recommended elements derive from the General, LifeCycle, Meta-Metadata, Educational, Rights and Classification Category of the IEEE LOM standard.

An important dimension for designing the ODS AP was the development of appropriate curriculum-based taxonomies covering all areas of school education, namely science, mathematics, ICT, social studies, arts and language learning. The taxonomies developed are in line with the taxonomies used in existing federated infrastructures discussed in Sect. 2.3. Moreover, these taxonomies have been stored in the vocabulary bank of the ODS portal architecture that enables the maintenance and interlinking of the taxonomies used by the ODS portal. The vocabulary bank also offers multilingual support, as well as export in a suitable linked data format (e.g. SKOS). The vocabulary bank has been implemented based on Tema Tres (http://www.vocabularyserver.com/), an open source vocabulary server to manage and exploit vocabularies, thesauri, taxonomies and formal representations of knowledge. Tema Tres is able to manage relations between vocabularies and supports different relationships between terms, i.e. hierarchical relations, symmetrical relations and equivalence relations.

The ODS metadata harvester and social data harvester are implemented based on the ARIADNE architecture (Ternier et al. 2009) which is a standard-based architecture for harvesting LOs in an open and scalable way. The architecture supports the integration of LOs in multiple, distributed repository networks. ODS provides support to content providers in creating a mapping from the provider metadata format to the IEEE LOM standard-based ODS AP. In order to ensure that only ODS AP-compliant metadata records arrive in the harvested metadata store, the ARIADNE metadata validation service is used for checking records against the ODS AP. This service builds on XML Schema (XSD), Schematron rules and special purpose components to check for compliance. This is necessary because metadata instances that are harvested contain errors (e.g. not all mandatory fields available, empty fields, syntactic errors, etc.). Implementing the rules that are specified in the ODS AP, the validation results are returned to the originating metadata repository to enable providers to correct the errors.

6 Conclusions and Future Work

Within the landscape of the emerging OER paradigm, valuable OERs in the form of LOs are scattered over different LORs and this creates barriers for end users to easily access them. Thus, in this chapter we presented the ODS portal, which aims to (a) build a federated infrastructure for a super-repository on top of existing LORs and federated infrastructures and (b) provide social features for building and sustaining web-based educational communities and communities of best teaching practices.

At the time of writing,[9] the ODS portal included more than 665,000 LOs from more than 30 external LORs and federated infrastructures. Connections are being made with other repositories that will bring in even more LOs. The main target of the ODS portal is to include 1.5 million LOs by 2015. Moreover, there are more than

[9] November 2013.

550 teachers registered in the ODS portal. This number will continue increasing, since the ODS portal is expected to be demonstrated and evaluated by 2,000 schools around Europe. This will create a large network of school teachers, who will be creating and sharing their own LOs used in schools around Europe. Finally, the ODS portal will create a unique cloud infrastructure that will facilitate schools around Europe to deploy lightweight portals accommodating their own LOs, which can be easily incorporated in any existing school course management system (CMS).

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

References

Avison, D. E., & Shah, H. U. (1997). *The information systems development life cycle: A first course in information systems*. New York: McGraw-Hill.

Bienkowski, M., Brecht, J., & Klo, J. (2012). *The learning registry: Building a foundation for learning resource analytics*. In Proceedings of the 2nd international conference on learning analytics and knowledge (pp. 208–211). Canada: Vancouver.

Caswell, T., Henson, S., Jensen, M., & Wiley, D. (2008). Open educational resources: Enabling universal education. *The International Review of Research in Open and Distance Learning, 9*(1), 1–11.

Duval, E., Smith, N., & Van Coillie, M. (2006). *Application profiles for learning*. In Proceedings of the 6th IEEE international conference on advanced learning technologies (ICALT 2006) (pp. 242–246). The Netherlands, IEEE Computer Society.

Ehlers, U. D. (2011). Extending the territory: From open educational resources to open educational practices. *Journal of Open, Flexible, and Distance Learning, 15*(2), 1–10.

Geser, G. (2007). Open educational practices and resources: OLCOS Roadmap 2012. Salzburg: Salzburg Research Edumedia Research Group. http://www.olcos.org/cms/upload/docs/olcos_roadmap.pdf. Accessed 30 Oct 2013.

IEEE Learning Technology Standards Committee (LTSC). (2005). Final standard for learning object metadata. http://ltsc.ieee.org/wg12/files/IEEE_1484_12_03_d8_submitted.pdf. Accessed 31 May 2013.

IMS Global Learning Consortium (GLC). (2005). IMS application profile guidelines overview. http://www.imsglobal.org/ap/apv1p0/imsap_oviewv1p0.html. Accessed 31 Oct 2013.

Kalz, M., Specht, M., Nadolski, R., Bastiaens, Y., Leirs, N., & Pawlowski, J. (2010). OpenScout: Competence based management education with community-improved open educational resources. In Halley et al. (Ed.), *Proceedings of the 17th EDINEB conference: Crossing borders in education and work-based learning* (pp. 137–146). Maastricht: FEBA ERD.

Klerkx, J., Vandeputte, B., Parra Chico, G., Santos Odriozola, J. L., Van Assche, F., & Duval, E. (2010). How to share and reuse learning resources: The Ariadne experience. In M. Wolpers, P. Kirschner, M. Scheffel, S. Lindstaedt, & V. Dimitrova (Eds.), *EC-TEL 2010. LNCS, 6383* (pp. 183–196). Heidelberg: Springer.

Manouselis, N., Kastrantas, K., Sanchez-Alonso, S., Cáceres, J., Ebner, H., Palmer, M., & Naeve, A. (2009). Architecture of the organic. Edunet web portal. *International Journal of Web Portals (IJWB),* 1(1), 71–91.

Massart, D. (2009). *Towards a pan-European learning resource exchange infrastructure*. In Proceedings of the 7th conference on Next Generation Information Technologies and Systems (NGITS'2009) (pp. 121–132). Berlin: Springer.

McGreal, R. (2008). A typology of learning object repositories. In H. Adelsberger, Kinshuk, J. Pawlovski, & D. Sampson (Eds.), *International handbook on information technologies for education and training* (2nd ed., pp. 5–18). Springer.

Prause, C., Ternier, S., de Jong, T., Apelt, S., Scholten, M., Wolpers, M., Eisen-hauer, M., Vandeputte, B., Specht, M., & Duval, E. (2007). Unifying learning object repositories in MACE. In D. Massart, J. Colin, & F. Assche (Eds.), *Proceedings of the first international workshop on learning object discovery and exchange (LODE'07)* (Vol. 311). Crete: CEUR Workshop. http://CEUR-WS.org/.

Schmitz, H. C., Wolpers, M., Kirschenmann, U., & Niemann, K. (2012). Contextualized attention metadata. In C. Roda (Ed.), *Human attention in digital environments*. Cambridge: Cambridge University Press.

Ternier, S., Verbert, K., Parra, G., Vandeputte, B., Klerkx, J., Duval, E., Ordonez, V., & Ochoa, X. (2009). *The Ariadne infrastructure for managing and storing metadata*. *IEEE Internet Computing,* 13(4), 18–25.

Totschnig, M. (2007). Open ICOPER content space implementation of 2nd generation of open ICOPER content space including integration mini case studies, ICOPER.

UNESCO. (2011). ICT competency framework for teachers. http://unesdoc.unesco.org/images/0021/002134/213475e.pdf. Accessed 30 Oct 2013

UNESCO. (2002). Forum on the impact of open courseware for higher education in developing countries—final report. http://unesdoc.unesco.org/images/0012/001285/128515e.pdf. Accessed 30 Oct 2013.

Walsh, T. (2010). *Unlocking the gates: How and why leading universities are opening up access to their courses*. Princeton: Princeton University Press.

Chapter 3
The Evolution of University Open Courses in Transforming Learning: Experiences from Mainland China

Ronghuai Huang, Liang Yu and Junfeng Yang

1 The Evolution Route of University Open Courses in the Past 20 Years

Over the past 20 years, as educators have been increasingly experienced with various pedagogies and interactive technologies, the concept of a "course" has been significantly changed, especially from the perspective of open course in higher education.

Traditionally, in higher education, a "course" is a teaching unit that lasts one academic semester, which is led by one or more instructors, and has a fixed roster of students. Students may receive a grade and credit after completing the course. Generally speaking, a course should contain elements of instructors, students, content, interaction between the teacher and students, evaluation, etc.

In 1992, when the World Wide Web was launched, open information resources rapidly became freely available, although they were of widely varying quality. Online courses were developed and disseminated by open universities for distance education. At that time, although some courses were called open courses, they were not free and not open to all learners, instructors, and researchers.

Open courses went free to all learners and instructors since the Massachusetts Institute of Technology (MIT) OpenCourseWare (OCW) was announced in 2001 and

R. Huang (✉)
Faculty of Education, Beijing Normal University, No. 19, XinJieKouWai St.,
HaiDian District, 100875 Beijing, P. R. China
e-mail: Ronghuai.huang@gmail.com

L. Yu
College of Computer and Information Science, Southwest University,
No. 2 Tiansheng Road, BeiBei District, 400715 Chongqing, P. R. China
e-mail: toliangyu@gmail.com

J. Yang
Education School, Hangzhou Normal University, 16 Xuelin St.,
Xiasha Higher Education Zone, 310036 Hangzhou, Zhejiang Province, P. R. China
e-mail: yangjunfengphd@gmail.com

D. G. Sampson et al. (eds.), *Digital Systems for Open Access to Formal and Informal Learning*,
DOI 10.1007/978-3-319-02264-2_3,

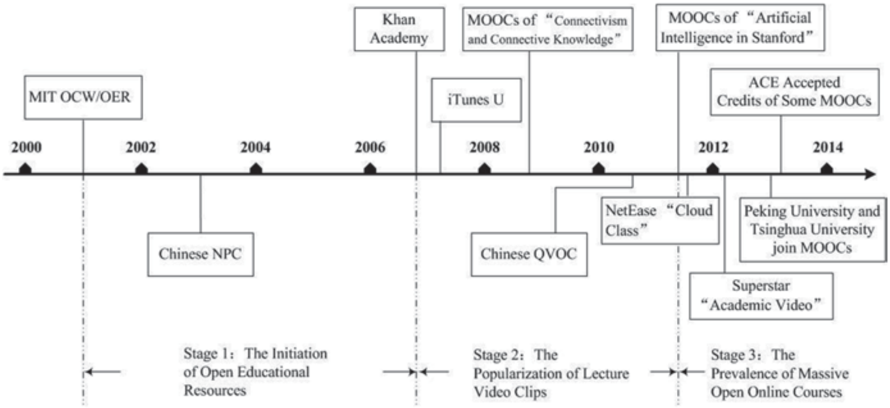


Fig. 3.1 Evolution route of open courses in terms of "big" events

launched in 2003, with the aim to put all the educational materials of undergraduate- and graduate-level courses online (Abelson 2008). MIT OCW was part of the Open Educational Resources (OER) Initiative supported by the Hewlett Foundation from 2002, the aim of which was to help equalize access to knowledge and educational opportunities across the world. OERs 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 William and Flora Hewlett Foundation 2002). The main objective of the OER/OCW was to broaden the access of learning materials to give more and more people access to high-quality resources. It was open, but the teaching and learning processes were missing in OER/OCW, of which the lack of student-to-student interactions was vital.

Since 2006, Khan Academy became well known for its micro video lectures on various subjects; a similar and popular video lectures project, the Open Yale Courses, was offered to share lectures recorded in the Yale College classroom in video, audio, and text transcript formats since December 2007. Such video open courses were popular because they met people's microlearning needs, but the interaction and evaluation were missing in these video open courses, which meant that the video open courses were good resources but not high-quality courses.

Massive open online courses (MOOCs) were first applied in 2008 to describe a particular model of open online courses developed by Stephen Downes and George Siemens (Boyatt et al. 2014). The concept of the MOOC has extended to denote almost all courses offered for free, online, and at scale. As a new and emerging type of course, MOOCs fully utilize technologies to support interaction between the teachers and learners, and among learners, which enhanced the learning outcome. However, the balance of scale and personal learning quality is a big issue for MOOCs.

The review of open course development provides a great understanding of three different stages of an open course, which are open education resources, open video courses (OVC), and MOOCs, as shown in Fig. 3.1. Different stages had different emphasis, and open courses evolved in a way of concerning more of learners and learning, which promoted personal learning. Therefore, in Sect. 2, 3, and 4, we discuss and explain the three stages and projects in detail to depict the evolution route of open courses and specifically describe the projects of these three stages in China, as shown in Fig. 3.1.

2 The Initiation of Open Educational Resources

The first stage of open course started from the initiation of OER. OER came to public attention in 2002 at a conference hosted by UNESCO, in which OER was defined as: "The open provision of educational resources, enabled by information and communication technologies, for consultation, use and adaptation by a community of users for non-commercial purposes." As the OER movement has grown, the definitions have moved from an initial description of the materials to include the tools needed to support OER to eventually a philosophy. The most cited OER definition was: "Open Educational Resources are digitized materials offered freely and openly for educators, students and self-learners to use and re-use for teaching, learning and research" (Hylén 2006). OER initiation aspired to provide open access to high-quality education resources. From large institution-based or institution-supported initiations to numerous small-scale activities, the number of OER-related programs and projects has been growing fast within the past dozens of years and the influence has permeated all over the world.

2.1 The Most Popular Project with Free Online Course Materials in Higher Education: MIT OpenCourseWare

In April 2001, MIT announced their intention to publish core educational materials, including syllabus, lecture notes, assignments, and examinations, from all of its courses freely and openly on the Web for use by educators and learners through a project called "MIT OCW." This project was originally envisioned by MIT, encompassing the core documents provided to students in an MIT classroom setting, plus other digital resources, such as simulations, animations, and sample code; subsequent projects at MIT and elsewhere had extended the OCW concept to include materials specifically designed for free and open use through the Internet.

MIT OCW was officially launched in October 2003. It covered materials from more than 2,080 MIT courses offered at both undergraduate and graduate levels, providing a comprehensive view into MIT's curriculum. MIT OCW educational materials had attracted about 100 million individuals who learned through the main site; translation sites shared 1,000 versions of MIT courses in languages including Chinese, Spanish, Portuguese, Farsi, and Thai; more than 290 copies of the site were distributed to universities in bandwidth-constrained regions (Carson et al. 2012).

MIT OCW received upwards of 1.5 million visits each month. Students had grown to 42 % of the audience, and educators and independent learners now constituted 9 % and 43 % of the visitors, respectively. Of the educators, 12 % responding to a March 2010 visitor survey indicated that they do incorporate OCW materials into their own content as anticipated, but educators more frequently used OCW for personal learning (37 %), to adopt new teaching methods (18 %), and as a reference for their students (16 %). Independent learners use OCW in a variety of personal (41 %) and professional (50 %) contexts, including home-schooling children and keeping up on developments in their professional field. Of the visitors, 66 % indicated they were mostly or completely successful at meeting their educational goals for visiting the site (d'Oliveira 2010).

2.2 The Most Influential National Program to Promote Curriculum Quality through Open Course: National Pilot Curriculum in China

In 2003, the National Pilot Curriculum (NPC) was initiated by the Ministry of Education (MOE) of China. The main goals of the NPC project were to promote teaching contents' reform and modernization, to reconstruct the management system of high-quality courses, and to enhance course system reorganization (Wang and Zhao 2011).

The procedure of NPC design and development followed the following steps: (1) unprompted development of courses, (2) recommendation by autonomous regions and municipalities, (3) evaluation by the MOE, and (4) allocation of financial support. The state and municipal education bureaus and colleges would increase the funds allotted for the quality courses development. There were three types of pilot curricula: regular undergraduate courses, vocational college courses, and online education courses, of which regular undergraduate courses occupied a large proportion. The following seven aspects were the key to ensure the quality of each course: (1) set scientific construction plan, (2) strengthen the construction of a teaching team, (3) emphasize teaching content and curriculum system reform, (4) emphasize the utilization of advanced teaching methods and means, (5) emphasize the construction of teaching materials, (6) attach importance to both theoretical teaching and practical teaching, and (7) establish an effective incentive and assessment mechanism. During the 8 years from 2003 to 2010, China has developed 3,790 NPCs of which 2,525 were regular undergraduate courses and 1,265 were vocational college and online education courses. The annual number for each type of NPC courses is shown in Table 3.1 (Li 2013). In addition, pilot curricula were also developed at the university level, municipal level, and provincial level, and the total number of pilot curricula is nearly ten times more than the NPC.

In 2007, the portal for all NPCs was set up by the Higher Education Press. For each course, the portal imported a number of resources into a resource database so that students could use individual PDFs, videos, and other resources without

Table 3.1 The annual number of national pilot curricula from 2003 to 2010

Years	2003	2004	2005	2006	2007	2008	2009	2010
The number of national pilot curricula for undergraduates	127	248	239	254	411	400	404	442
The number of national pilot curricula for vocational colleges	24	51	59	106	200	199	194	223
The number of national pilot curricula for online education	0	0	0	0	49	50	50	60
The sum of national pilot curricula	151	299	298	360	660	649	648	725

leaving the portal or referring to other sites. There are many social "Web 2.0" features: Users who logged in could save links to courses on their personal page, rate courses, or write comments. Users could also post comments or questions on specific resources. Courses that matched the visitor's profile or were similar to those accessed by him/her were automatically pushed to the visitor. In addition to featuring all the NPC, the site was a clearing house for information about the project, with updated policies and latest news, information on admission, forthcoming courses and seminars, etc.

Until May 2011, the total number of users' visits to the website had reached 11,615,023; 1,301,232 various formats of resources had been posted; and 214,010 downloads had been recorded (Wang and Zhao 2011). More than a million registered users, including 403,620 who registered with real name and coordinates, visited the website frequently. Of the visitors, 49% were students and 40% were teachers.

The first stage of an open course could be defined as the initiation of OERs. The main goal of this stage was to provide private and high-quality teaching materials. OER focused on providing syllabuses, notes, reading lists, video lecture, teaching calendar, and many other static resources, and intends to build the free sharing mechanism and complete project workflow. While OER had promoted the openness of learning, the relationship between teachers and students was not rebuilt, which resulted in no interactions and assessments.

3 The Popularization of Lecture Video Clips Through Internet

In 2007, Jonathan Bergmann and Aaron Sams, and some other chemistry teachers from Woodland Park High School, recorded and annotated lessons and posted them online in order to reteach lessons for absent students. Absent students appreciated the opportunity to see what they had missed. Surprisingly, not only did the absent students often use the materials but also students who had not missed classes used the online material, mostly to review and reinforce classroom lessons. With these teacher-created videos and interactive lessons, instructions that used to be given in class now could be accessed at home. As a result, the class became the place to work through problems, advance concepts, and engage in collaborative learning (Tucker 2012). This kind of class is called a flipped class. Fulton (2012) listed the following advantages of a flipped class: (1) Students move at their own pace; (2) doing "homework" in class gives teachers better insight into student difficulties and learning styles; (3) teachers can more easily customize and update the curriculum and provide it to students 24/7; (4) classroom time can be used more effectively and creatively; (5) teachers using the method report seeing increased levels of student achievement, interest, and engagement; (6) learning theory supports the new approaches; and (7) the use of technology is flexible and appropriate for "twenty-first-century learning."

The video lectures were core instructional materials of the flipped classroom for the students especially in higher education. At the second stage of open courses, video lectures became popular to enhance learning.

3.1 Illumination of Flipped Classes via Using Educational Video Clips: Khan Academy

Khan Academy is a nonprofit educational website created in 2006 by Salman Khan, a graduate of MIT and Harvard Business School with the goal of changing education by providing free world-class education for anyone, anywhere. The website supplies a free online collection of more than 4,500 micro lectures via video tutorials stored on YouTube, teaching mathematics, history, health care, medicine, finance, physics, chemistry, biology, computer science, etc. Khan Academy has delivered more than 260 million lectures.

The project is funded by kind donations. Khan Academy is a not-for-profit organization, now with significant backing from the Bill and Melinda Gates Foundation and Google. Several people have made contributions worth US$ 10,000; Ann and John Doerr contributed US$ 100,000; and the total revenue is about US$ 150,000 in donations. Additionally, it earned US$ 2,000 per month from ads on the website in 2010 until Khan Academy ceased to accept advertising (Young 2013). In 2010, Google announced it would give Khan Academy US$ 2 million for creating more courses and for translating the core library into the world's most widely spoken languages, as part of their Project 10100. In 2013, Carlos Slim made a donation to Khan Academy to expand its Spanish library of videos (Tyler 2013).

Khan Academy has eclipsed MIT's OCW in terms of videos viewed. Its YouTube channel has more than 283 million total views compared to MIT's 52 million. It also has more than twice as many subscribers with 1,233,000. Khan Academy currently provides various levels of mathematics courses, and Salman Khan has stated that (with the help of volunteers) they now have topics beyond just mathematics, such as physics, chemistry, finance, computer science, logic, and grammar (Wikipedia 2013). Khan Academy also had a language release in mid-2012. It was supported by volunteers from Amara and included Indonesian, German, Spanish, French, Italian, Chinese, etc.

3.2 The Pool of Lecture Video Clips of Elite Universities: iTunes U

In May 2007, Apple developed an education channel on iTunes, wherein the users could access the education channel by the app iTunes U. Initially, iTunes U mainly provided audios, videos, and various kinds of documents from elite universities, such as Stanford, Yale, Cambridge, and Oxford. Later, Apple added the social learning parts such as discussions and homework to the iTunes U app. As an outstanding sign for mobile applications, iTunes U has gradually increased its impact. iTunes U collected countless instructional media including video courses, audio courses, PDF courseware, and other media courses from universities and educational institutions; users can download these resources freely. Users can synchronize these resources to an iPod or iPhone and can also first download these m4v and mp4 videos and then copy these resources to other equipments. Furthermore, iTunes U provides more than 50 million sets of lectures, videos, eBooks, and other resources for free, and these resources cover thousands of different subjects. Up to March 2013, users had downloaded iTunes U more than a billion times. More than 1,200 universities and colleges with 1,200 K–12 (American elementary education) schools had developed more than 2,500 public courses and thousands of private courses. These courses covered arts, science, health care, medical, education, business, and other fields. Parts of the courses on iTunes U were very popular, such as more than 10 million learners downloaded the course “General Chemistry” of Ohio State University. Educators developed iTunes U courses in 30 countries including Brazil, Korea, Turkey, and UAE; learners from 155 countries were able to access these courses and other educational contents by iTunes U. According to the statistical data from Apple, 60 % learners outside the USA downloaded iTunes U courses.

3.3 The National Program of Lecture Video Clips: Quality Video Open Course in China

In 2011, the MOE of China initiated Quality Video Open Course (QVOC) to enhance the quality of higher education. QVOC was the online video course and academic lecture that dealt with the topic of education and cultural quality, and served mainly college students, being free to the public (Xie et al. 2013). QVOC focused on promoting the opening up of higher education, carrying forward socialist core values and the mainstream culture, broadly spreading the outstanding achievements of human civilization and the frontiers of modern science and technology. At the same time, it was also to enhance scientific culture literacy of college students and the public, serving the construction of an advanced socialist culture, improving China’s cultural soft power and the international influence of Chinese culture.

The construction of the QVOC was led by the government, developed by universities independently, evaluated by experts, teachers and students, and popularized by the public. The development mode of QVOC could be summarized as “planning the whole and selecting the best, development in batches and uploading online timely." "Planning the whole and selecting the best" means that the MOE first made integrated plans and standards, and then colleges and universities developed and evaluated QVOC based on their own characteristics independently. After that, colleges selected the best courses to run for the national QVOC. Lastly, the Ministry of Education invited experts to select excellent courses out of those declared courses. "Develop courses in batches and Upload to the Internet timely" referred to the fact that the MOE would select the QVOC by batches; once the batch of selected QVOC were developed, they would be uploaded concurrently to some sharing systems and certain public websites.

According to the plan of the MOE, during the Twelfth Five-Year Plan, the goal was to develop 1,000 quality video open classes, including the 100 quality video open classes that were finished in 2011 and the 900 that were to be developed during 2012–2015. Up to December 2012, 186 video open courses have been broadcasted on public websites, such as "Icourses," "CNTV," "NetEase," etc., in which users could get access to a course with high speed. Meanwhile, more and more university teachers propagated their courses via the Internet.

This stage of an open course showed some typical characteristics, including lecturers' unique charm of personality, distinct course structure, professional production, and flipped class. Feedback from teachers were noticed and employed to enhance learning, but the role of the teacher still remained as the content provider and instructor. Obviously, the video open courses did not provide students with consecutive learning support, which were important for maintaining student's learning motivation. Furthermore, no certification or credit for the learning experience was always the most important reason for college students' giving up the course.

4 The Prevalence of Massive Open Online Courses

MOOC was the emerging kind of online course aimed at large-scale interactive participation and open access via the Web. In addition to traditional course materials such as videos, readings, and problem sets, MOOCs provided interactive user forums to build a community for students, professors, and teaching assistants.

4.1 The Threshold of MOOCs in Elite Universities

The term MOOC was coined in 2008 by Dave Cormier and Bryan Alexander in response to a course called "Connectivism and Connective Knowledge" which was led by George Siemens from Athabasca University and Stephen Downes from the National Research Council. The course was selected by 25 tuition-paying students of extended education at the University of Manitoba as well as by more than 2,200 other students from the general public who took the online course for free. All of the course content was available through RSS feeds, and online students could participate through a variety of collaborative and social tools, such as blog posts, Moodle, and Second Life (Cormier 2013). After that, Jim Groom from the University of Mary Washington and Michael Branson Smith from the City University of New York adopted this course structure and hosted their own MOOCs through several universities. Early MOOCs departed from formats that relied on posted resources, learning management systems, and structures that mixed the learning management system with more open online resources (Masters 2011). MOOCs from private and nonprofit institutions emphasized prominent faculty members and expanded open offerings to existing subscribers into free and open online courses.

More than 1.5 million people have registered for classes through Coursera, Udacity, and EdX (Kolowich 2012). At the early stage, most of the researchers held that MOOCs could open up higher education to anyone anywhere, especially to underserved populations. In 2013, the range of students registered appeared to be broad, diverse, and nontraditional, but was more concentrated among English speakers. The first MOOC of Asia given by the Hong Kong University of Science and Technology through Coursera started in April 2013 with 17,000 registered students. The completion rates were typically very low, with a steep drop-off in student participation starting in the first week. In the course Bioelectricity at Duke University in 2012, 12,725 students enrolled, but only 7,761 ever watched a video, 3,658 attempted a quiz, 345 attempted the final examination, and 313 passed and earned a certificate (Catropa 2013). One online survey listed a "top ten" list of reasons for not completing a course (Colman 2013). These most common reasons were that the course required too much time, was too difficult, or conversely, was too basic. Reasons related to poor course design included "lecture fatigue" related to a perceived tendency to simply recreate the bricks-and-mortar course, lack of a proper introduction to course technology and format, and clunky technology and trolling on discussion boards. Hidden costs were cited including by those who found that required readings were from expensive texts written by the instructor. Other non-completers were "just shopping around" when they registered or were participating simply for the knowledge rather than for a credential.

On May 2013, Tsinghua University, Peking University, and Hong Kong University participated in the EdX platform. At the same time, Shanghai Jiao Tong University and Fudan University joined the Coursera Platform. Peking University has taken part in Coursera and has published seven courses so far (China Education Daily, 2013). With the tendency of opening access to higher education resources, more and more Chinese MOOCs are on the way.

A study by Kizilcec et al. (2013) identified four types of MOOC students: Auditors, who watched videos throughout the course, but took few quizzes or examinations; completers, who viewed most lectures and took part in most assessments; disengaging learners, who took part only at the start of the course; and sampling learners, who might only watch the lectures at various times during the course. Table 3.2 shows the percentages in each group from high school, undergraduate, and graduate levels.

Table 3.2 The percentages in each group

Course	Auditing	Completing	Disengaging	Sampling
High school	6%	27%	28%	39%
Undergraduate	6%	8%	12%	74%
Graduate	9%	5%	6%	80%

4.2 The Response to MOOCs from Chinese Industry

There were two typical MOOC projects in China: One was the NetEase Cloud Class and the other was the Superstar Academic Video, and both were from the Chinese industry. NetEase pushed out the project of "NetEase Cloud Class" in December 2012; NetEase Cloud Class was another important product for Chinese online education. At present, there are several kinds of courses to study on the NetEase Cloud Class, which involve "IT and Internet, "Career Skills," "Healthy Lifestyle," "Practical Software Skills," "Lectures," and so on. NetEase Cloud Class had unified learning management and provided an integral experience of videos, pictures, words, tests, and practices. Learners set up the learning plans, followed their plans, and evaluated the outcomes all by themselves. NetEase Cloud Class integrated the social learning network, which made the sharing of individual learning achievements available, such as resource bundles, plans, notes and learning processes, questions, and answers. Besides, learners could communicate with the teacher offline. Up to April 2013, 385 open courses had been developed and more than 100,000 online learners took part. The Superstar Academic Video (site: video.chaoxing.com) started in 2006 and was a profitable website for academic videos, run by the Beijing Century Superstar company. The Beijing Century Superstar company got copyrights by signing licenses with teachers. Every episode of video courses lasted 25 min, and some of the video courses could be watched freely. Up to April 2013, the Superstar Academic video had recorded classes and lectures of 5,410 famous teachers and experts and had made more than 79,980 video clips of courses, covering philosophy, literature, history, economics, law, engineering, science, arts, language, and many other disciplines.

MOOCs supported the learning process, brought in social learning network, and provided homework and online tests. MOOCs' learning materials include syllabuses, personal learning plans, lecture notes, teaching videos, and other kinds of media. In MOOCs, teachers were just the supporters who provided knowledge and answered questions for students. MOOCs provided more interactive modes, supporting the interaction between teachers and students and students and students by using social learning networks. Students were able to get real-time feedback from teachers. These interactive modes could improve students' learning.

5 The Implication of Open Courses in Transforming Learning

It is clear that the evolution route of open courses consisted of three stages, which were characterized separately by sharing digital course materials, sharing high-quality video clips, and sharing all the course process. In the first stage, the main aim was to let more people get access to learning resources by digitalizing the textbook and learning content; in the second stage, the objective was to enhance learning by digitalizing the teaching process; in the third stage, the goal was to get massive learners included by digitalizing the interactions between teachers and students.

Global Education First Initiative (GEFI) was launched by the United Nations (UN) in September 2012 with the three priorities of putting every child in school, improving the quality of learning, and fostering global citizenship (UN 2012). Scaling up quality educational chances and resources were very important for accomplishing the three priorities, and open courses had played an important role in the process of scaling up qualified education.

5.1 The Framework for Watching Open Courses

As education becomes more and more open to learners, the analysis of how to make sure open courses send quality learning to students seems critical for the development of open courses. The review of the development and evolution of open courses provided a great understanding of open courses in a framework to describe the different characters and emphasis at different stages, as shown in Table 3.3. Content and media; roles of teachers, feedback, and interactions; assessment and qualification; and target audience are the five indicators of the framework. The five indicators are crucial for evaluating the quality of online courses. Content and media are the core elements of an online course; the role of teachers reflects the basic philosophy of course development; feedback and interaction play critical roles to promote learning, assessment, and qualification indicate the evaluation methods; and the target audience becomes more and more open. Obviously, this is the overall evaluation of different kinds of open courses, because there are some expectations in each stage.

At first, open courses were developed with a teacher-centered philosophy, the content was mainly text-based materials in a course website, and there was little interaction between teachers and students. Later, student-centered philosophy was considered in open video courses (OVC), but most courses were still developed in teacher-centered philosophy with micro video clips broadcasted through an open platform. There was some interaction between teachers and students or among students. MOOCs were developed with student-centered philosophy and provided rich-media learning materials. The feedback from teachers and interactions among students became one part of the learning process in MOOCs. The assessment methods were flexible and more process based, and credits from some MOOCs were accepted by others. The providers of online open courses were initially universities, but they became more open as companies and third party institutions were also included.

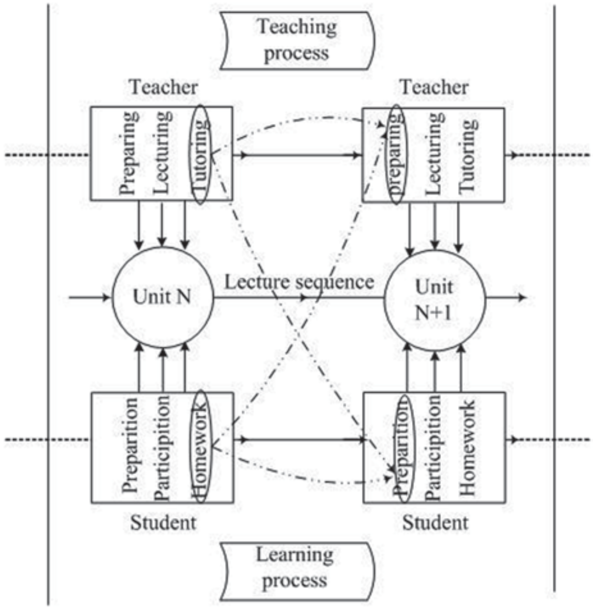


Fig. 3.2 Learning process in traditional course

5.2 The Coupling of Learning And Teaching Process In Open Courses

The above indicator analysis showed that the development philosophy of open courses had changed to being more student centered and learners were more considered in the whole learning process through open courses. However, the learning process was quite different between traditional courses and open courses. In traditional courses, the learning and teaching processes always occurred at the same time and matched each other closely together just like a zipper, as shown in Fig. 3.2. As a result of "zipper" of teaching and learning processes, the students were always able to learn effectively in traditional courses compared with open courses.

The learning process in open courses was quite different, as shown in Fig. 3.3. The teaching process had been done in the production of course, but the learning process happened when students learn the course. So the key issue for open course design should be to couple the teaching process and the learning process like a zipper in the traditional course through different ways, such as feedback and interaction. At the same time, connected learning, with the characteristics of autonomy, enquiry, and collaboration, is the new kind of learning preferred by learners (Huang et al. 2013). Therefore, learning process should be considered in the design stage of an open course, and the feedback and interaction should be designed to enhance learning by using emerging social technologies.

Table 3.3 Dimensions of open courses

Indicator	Categories / Main Features	Early OER	OVC	MOOC (xMOOCs, cMOOCs)
Content & Media	The media of learning content: (1) Hyper-text and Hyper-media; (2)Video Clips; (3) Rich Media	1	2	3
	Roles of Textbook: (1)Focused on textbook; (2) Beyond textbook	1	2	2
Roles of Teacher	Teacher as (1)Content provider; (2) Instructor; (3) Facilitator	1, 2	1, 2	1, 3
Feedback & Interaction	Feedback from teacher	None	Weak	Strong
	Social interaction	Weak	Strong	Stronger
Assessment & Qualification	Assessment via (1) Test; (2) Contribution; (3) Product	1	None	1, 2, 3
	Qualification by (1) University; (2) Public	1	1	2
	Credits accepted by others	None	None	Weak
Target Audience	Audience: (1)Students in their universities, (2) students in other universities (3) Public	1, 2	1,2	1, 2, 3
	Course provider: (1) non-profit, (2) profit	1	1	1,2

5.3 The Positive Reaction to MOOCs from the Chinese Government

The MOE of China has noticed the rapid evolution of MOOCs and realized the importance of developing MOOCs. Several high -level forums have been held to discuss the issues of MOOCs, and the following four research questions need to be answered before MOOCs are developed at the national level. (1) Which level of education should develop MOOCs, what kinds of courses are suitable to become MOOCs, and what kinds of learners are available to learn MOOCs? (2) How to carry out instructional design for MOOCs, how to deal with the interactions between students and students or teachers, and what teaching principles should MOOCs adhere to? (3) Who will provide MOOCs and why they provide MOOCs, what is the business model for MOOCs, and what is the service MOOCs will provide? (4) What

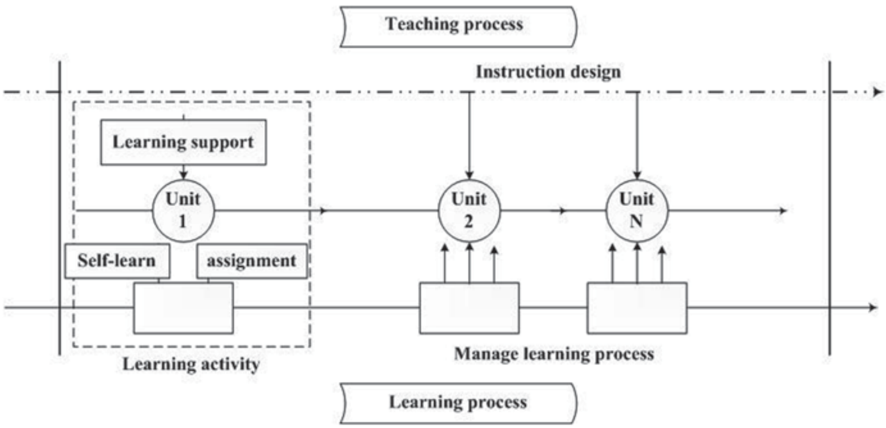


Fig. 3.3 Learning process in open course

impacts on cultural, work, economic, and political activities will MOOCs bring about?

The reviewing of the evolution route on open courses provided us a profound understanding that the following conclusion would be available no matter what strategies should be adopted to develop MOOCs. First, the universities are undergoing a transforming phase of reconstructing course system, revolutionizing teaching and learning methods, and changing patterns of providing education. Second, the transformation of teaching ways must match with the transformation of learning ways, transformation of learning ways must match with the transformation of learning content, and transformation of learning content must match with the transformation of learning goals. Third, the new learning ways are characterized by multi-type of resources, free choice of learning devices, full consideration of diversity, and deep immersing of experience. Fourth, it is an important way for reshaping learning and promoting quality recourses sharing by developing MOOCs. Fifth, the developing MOOCs in different areas may benefit both social and economic purposes, for instance, MOOCs in the teacher-training area.

References

Abelson, H. (2008). The creation of OpenCourseWare at MIT. *Journal of Science Education and Technology, 17*(2), 164–174. Retrieved on October 5, 2013, from http://link.springer.com/article/10.1007/s10956-007-9060-8

Boyatt, R., Joy, M., Rocks, C., & Sinclair, J. (2014). What (Use) is a MOOC? In L. Uden, Y.-H. Tao, H.-C. Yang, & I.-H. Ting (Eds.), *The 2nd International Workshop on Learning Technology for Education in Cloud SE—15* (pp. 133–145). Berlin, Germany: Springer-Verlag. doi:10.1007/978-94-007-7308-0_15

Carson, S., Kanchanaraksa, S., Gooding, I., Mulder, F., & Schuwer, R. (2012). Impact of OpenCourseWare publication on higher education participation and student recruitment. *The International Review of Research in Open and Distance Learning, 13*(4), 19–32.

Catropa, D. (2013, February 24). *Big (MOOC) data* (Web log message). Retrieved on September 28, 2013, from http://www.insidehighered.com/blogs/stratedgy/big-mooc-data.
China Education Daily (2013, September 26). *What is the challenge for higher education when MOOCs come?* (Online forum comment). Retrieved on October 3, 2013, from http://paper.jyb.cn/zgjyb/html/2013-09/26/content_190993.htm?div=-1
Colman, D. (2013, April 5). MOOC Interrupted: Top 10 reasons our readers didn't finish a massive open online course (Web log message). Retrieved on September 20, 2013, from http://www.openculture.com/2013/04/10_reasons_you_didnt_complete_a_mooc.html.
Cormier, D. (2008, October 2).*The CCK08 MOOC—Connectivism course, 1/4 way* (Web log message). Retrieved on October 8, 2013, from http://davecormier.com/edblog/2008/10/02/the-cck08-mooc-connectivism-course-14-way/.
d'Oliveira, C., Carson, S., James, K., & Lazarus, J. (2010). MIT OpenCourseWare: Unlocking knowledge, empowering minds. *Science*, *329*(5991), 525–526.
Fulton, K. (2012). Upside down and inside out: Flip your classroom to improve student learning. *Learning & Leading with Technology, 39*(8), 12–17.
Huang, R., Chen, G., Yang, J., & Loewen, J. (2013). The new shape of learning: adapting to social changes in the information society. In R. Huang & J. M. Spector (Eds.), *Reshaping learning, new frontiers of educational research* (pp. 3–42). Berlin, Germany: Springer-Verlag. doi:10.1007/978-3-642-32301-0_1
Hylén, J. (2006). Open Educational Resources – Opportunities and challenges. Retrieved on September 9, 2013, from http://www.oecd.org/dataoecd/5/47/37351085.pdf.
Kizilcec, R. F., Piech, C., & Schneider, E. (2013). Deconstructing disengagement: Analyzing learner subpopulations in massive open online courses. *Third International Conference on Learning Analytics and Knowledge,* LAK '13 Leuven, Belgium.
Kolowich, S. (2012, June 11). *How will MOOCs make money?* (Web log message). Retrieved on September 5, 2013, from http://www.insidehighered.com/news/2012/06/11/experts-speculate-possible-business-models-mooc-providers.
Li, Y., Zhou, Y., & Zeng, L. (2013). Pilot curriculum in China: The practice of promoting the quality of higher education. In R. Huang & J. M. Spector (Eds.), *Reshaping learning, new frontiers of educational research* (pp. 209–234). Berlin: Springer.
Masters, K. (2011). A brief guide to understanding MOOCs. *The Internet Journal of Medical Education,* 1(2). Retrieved on September 15, 2013, from http://ispub.com/IJME/1/2/10995.
The William and Flora Hewlett Foundation (2012, July 23). *Open educational resources* (Electronic mailing list message). Retrieved on September 11, 2013, from http://www.hewlett.org/programs/education-program/open-educational-resources.
Tucker, B. (2012). The flipped classroom. *Education Next*, 12(1), 82–83.
Tyler, J. (2013, January 15). *Mexico's Carlos Slim funds Khan Academy in Spanish* (Video file). Retrieved on September 9, 2013, from http://www.marketplace.org/topics/life/education/mexicos-carlos-slim-funds-khan-academy-spanish.
UNESCO. (2002). *Forum on the impact of open courseware for higher education in developing countries: Final report*. Paris: UNESCO.
U. N. (2013). *Global education first initiative*. Retrieved on October 27, 2013, from http://www.globaleducationfirst.org/289.htm.
Wang, C., & Zhao, G. (2011). *Open education resources in People's Republic of China: Achievements, challenges and prospects for development*. Retrieved on October 2, 2013, from http://iite.unesco.org/pics/publications/en/files/3214700.pdf.
Wikipedia (2013, October 8). Khan Academy (Web log message). Retrieved on October 2, 2013, from http://en.wikipedia.org/wiki/Khan_Academy.
Xie, Y., Yin, R., Wang, Q., Li, G., & Peng, L. (2013). Analysis on instructional features of quality video open course. In: S. K. S. Cheung, J. Fong, W. Fong, F. L. Wang, L. F. Kwok (Eds.), *Hybrid learning and continuing education* (pp. 322–333). Toronto: Springer Berlin Heidelberg
Young, J. R. (2010, June 6). *College 2.0: A self-appointed teacher runs a one-man 'academy' on youtube* (Online forum comment). Retrieved on September 7, 2013, from http://chronicle.com/article/A-Self-Appointed-Teacher-Runs/65793/

Chapter 4
Massive Open Online Courses (MOOCs) and Massively Multiplayer Online Games (MMOGs): Synergies and Lessons to Be Learned

Iro Voulgari and Demetrios G. Sampson

1 Introduction

With the development of computer-supported collaborative learning environments and the establishment of Web 2.0 technologies, such as social networking platforms and Wikis, a new dimension to learning is emerging: extensively distributed, large, and self-managed virtual teams interact and collaborate practicing what Kafai and Peppler (2011) refer to as computer-supported *collective learning*. This collective dimension to learning is gradually integrating with the traditional practices of formal education aiming to address the needs and expectations of the new generation of empowered and reflective learners.

Within this framework, a new trend in distance online learning environments is emerging: the Massive Open Online Courses (MOOCs). Although MOOCs are widely discussed as potential alternatives to traditional university courses, still there are several challenges for their pedagogically effective design (Johnson et al. 2013). More specifically, MOOCs are facing the challenge of designing learner-centered online courses for the masses, rather than just provide open access to static educational resources. Thus, MOOCs' design involves, among others, the pedagogically meaningful and effective handling of massive numbers of people and of massive volumes of educational resources. Although peer-reviewed literature on MOOCs is still limited, a number of challenges have been identified. These challenges mainly involve the effective engagement of massive number of people and the management

I. Voulgari (✉)
Department of Digital Systems, University of Piraeus, 150 Androutsou Odyssea Street, GR-18532 Piraeus, Greece
e-mail: avoulgari@upatras.gr

D. G. Sampson
Department of Digital Systems, University of Piraeus, 150 Androutsou Odyssea Street, GR-18532 Piraeus, Greece
e-mail: sampson@unipi.gr

Information Technologies Institute, Centre for Research and Technology—Hellas, Thessaloniki, Greece
e-mail: sampson@iti.gr

D. G. Sampson et al. (eds.), *Digital Systems for Open Access to Formal and Informal Learning,*
DOI 10.1007/978-3-319-02264-2_4, © Springer International Publishing Switzerland 2014

of massive volumes of educational resources. On the other hand, research in the educational exploitation of Massively Multiplayer Online Games (MMOGs) may provide valuable insights on issues such as engagement, commitment, learner connectedness, and the distributed resources. These two seemingly different learning environments share two common characteristics: the emerging learning practices and the involvement of massive numbers of people, interactions, and materials. In both environments, people are communicating and interacting with the purpose to attain certain goals and progress within the environment. In this book chapter, we review the relevant literature and discuss possible synergies between MMOGs and MOOCs, and lessons to be learned from these synergies.

The idea of the benefits of online games for the design of MOOCs has already been raised (Morris and Stommel 2012; Murdoch 2013). Romero (2013) also recognized the potential of MMOGs to inform the design of MOOCs and discussed the design of a project on encouraging entrepreneurship through an MOOC integrating a Massive Multiplayer Online Serious Game. Building upon this synergy, we identify pedagogical design challenges of MOOCs and attempt to draw useful insights from the lessons learned by research in the educational use of MMOGs.

2 MMOGs and MOOCs: Synergies

Effective learning environments and online learning environments, more specifically, rely on three main dimensions: the cognitive, the affective, and the social. The learning content, the cognitive processes triggered, as well as the interactions and the quality of communication among learners, and the motivation and engagement are all critical factors for the development of effective learning processes and the attainment of the learning objectives (Barron 2003; Jarvela et al. 2008; Sfard 1998; Van Den Bossche et al. 2006). The *cognitive presence,* as well as the *social presence* and the *teaching presence,* has been considered as critical indicators for the emergence of *communities of inquiry* in computer-mediated learning environments (Garrison et al. 1999). The social aspect more specifically, although critical for the development of social links, trust, cohesion, constructive communicative interactions, and the emergence of an active and vibrant community, is often the most challenging aspect for computer-mediated communication and collaboration environments (Kirschner and Van Bruggen 2004; Kreijns and Kirschner 2002; Strijbos et al. 2004).

Therefore, it is not surprising that the main pedagogical challenges of MOOCs are situated not only in the domain of the cognitive aspect and the attainment of the learning objectives but also in the social aspect (that is, the management of massive numbers of online learners with diverse backgrounds) and the affective aspect (that is, the motivation, engagement, and immersion of the learners). Research on online games, and particularly on MMOGs, and learning has been motivated by the indications that MMOGs, although not specifically designed for learning, can provide inspiration for the design of online learning environments and a new perspective for addressing these three dimensions (Ang and Zaphiris 2008; Dickey 2007; Freitas and Griffiths 2009; Schrader and McCreery 2008). Successful MMOGs engage millions of players worldwide, over long periods of time, even years. These players willingly commit to the arduous task of accomplishing the game goals, progressing, and reaching the higher levels of expertise in the game content. In the following sections, we address some of the main pedagogical design challenges of MOOCs and discuss the practices employed or emerging in MMOGs for addressing similar challenges.

3 Learning Processes, Practices, and Pedagogies

MOOCs are widely discussed as potential alternatives to traditional university courses. Yet, there are several challenges for their pedagogically effective design. More specifically, MOOCs are facing the challenge of designing learner-centered online courses for the masses, rather than just provide open access to static educational resources. On the other hand, MMOGs are studied as online environments with a potential for facilitating learning involving large numbers of learners. In this section, we discuss these two environments in relation to relevant learning theories.

Connectivism is the main learning theory claimed in MOOCs (Siemens 2005). Connectivism situates learning within social, distributed environments, and networks of people. Learning emerges through the access to and reflection on a variety of perspectives on a topic, and numerous, diverse, and distributed sources of learning materials. Learning is, therefore, highly participatory and self-directed (Cormier and Siemens 2010; Downes 2009; Siemens 2005).

MMOGs similarly rely on learning through interactions with others and participation in a *community of practice*. Players learn the game through their interactions with the digital environment and with each other, and through their participation in virtual communities beyond the boundaries of the game, such as fora, Wikis, the creation of content, content distribution, and networking sites. The players interact with the virtual environment, they reflect on their actions and approaches, solve problems, use trial and error, are rewarded for their successes, and they learn the game through their interactions with others. MMOGs are situated in the third generation in the history of games as described by Egenfeldt-Nielsen (2007), where the social dimension of the game and the player interactions are emphasized, and *social-constructivist theories* of learning seem to apply.

The learning practices of the players actually extend beyond the limits of the game environment. MMOG players spontaneously form online communities of learning, external to the game (Galarneau 2005). Players have reported that access to such resources is integral to their success in the game (Voulgari et al. 2013). A large part of the communication and interactions of MMOG players takes place beyond the limits of the virtual environment, in official or player-developed web sites, social media, and fora. Players ask and answer questions, exchange viewpoints, debate, share their achievements, and recruit group members. The game content extends beyond the boundaries of the game. The players develop and distribute their own content, user guides, tutorials, game videos, and a wide range of other digital artifacts;

they learn the game and solve the in-game problems through the help of others, and through their access to networks of expertise, to resources, tools, and technologies they trust. These networks of people, technologies, and products, for the acquisition of knowledge and expertise, constitute a unique learning model, which could inspire the traditional educational practices (Williamson and Facer 2004).

Although the *connectivist learning* approach seems to address the requirements of learning in the digital era, certain pitfalls have been identified. Connectivism presents the opportunity for new skills, knowledge, and mindsets (Cormier and Siemens 2010; Koutropoulos and Hogue 2012). This aspect, though, entails certain challenges for learners who are not familiar with this approach. It seems that learners who rely more on traditional models of teaching and learning struggle with the self-directed nature of MOOCs (Koutropoulos and Hogue 2012). The acquisition of expertise and learning in an MOOC requires reflection on practice, community support, and self-organization (Waite et al. 2013). The main elements of connectivist communities for learning, as described by Dowes (2009) (i.e., autonomy of the individuals, diversity of the members, openness of communication and interactions, the production of knowledge through interactivity and connectedness), may present limitations, particularly for novice MOOC learners. These limitations are relevant to the individual learning style, the level of expertise, the complexity of the content, and the engagement, the trust, and active participation of the learners (Mackness et al. 2010).

At this point, it has to be noted that two different types of MOOCs have been identified: xMOOCs and cMOOCs. cMOOCs, as open learning networks, are more consistent with the *connectivist approach* to learning. xMOOCs are related to more traditional approaches to online learning and adopt a rather conventional, *social-behaviorist* learning model (Mackness et al. 2010; Rodriguez 2012).

Over the past years, MMOGs are continuously evolving (through, for example updates and patches) to address problems relevant to the experience, the progress, and the management of the players in the game. This aims not only to maintain a technically stable environment but also to respond to any frustration reported by the players, to sustain motivation and engagement, to accommodate different playing styles, and, more effectively, support interaction among players and between players and the game environment. In the following sections, we review techniques and practices employed in MMOGs through the perspective of the challenges identified for MOOCs in an attempt to delineate relevant pedagogical design elements.

4 Engagement and Immersion

With a less than 10 % completion rate, one of the main challenges that MOOCs have to cope with is the high dropout rates (Cormier and Siemens 2010; Rodriguez 2012). Kizlcec and Piech (2013) further distinguished four clusters of MOOC learners in relation to their engagement: *completing* learners who complete the course content materials and the assessments; *auditing* learners who engage with the content but not the assessments and do not gain a course credit; *disengaging* learners who lose interest after, approximately, the first third of the course; and *sampling* learners who sample and explore the course material. The low completion rate can be partly attributed to the filtering of the learners after course registration (Cormier and Siemens 2010); learners first register to access and then assess whether the course materials and structure are interesting and suitable for them. A number of additional factors have been associated with the high dropout rates. MOOCs rely heavily on the motivation and determination of the learners (Levy 2011) as well as on commitment and immersion to the course (Chamberlin and Parish 2011; Morris and Stommel 2012).

In addition, the active participation of the learners is not always as high as expected. Only a small number of participants are actively contributing to course activities, such as blog posts, videos, or other digital artifacts, while the vast majority are "consumers" of existing materials (Kop and Carroll 2011; Rodriguez 2012). Novice learners in MOOCs have attributed their passive status to factors such as lack of confidence and trust. In addition, "lurkers" justified their lack of active participation with their preference to autonomous learning and to other commitments. Such phenomena suggest that active participation, creativity, engagement, immersion, and motivation of the MOOC learners need to be encouraged (Kop and Carroll 2011).

Engagement, motivation, and commitment of the participants are also critical objectives for MMOGs. Morris and Stommel (2012) have also observed the lack of immersion in MOOCs and referred to the paradigm of games. They suggested that learning in distance education could become more immersive and engaging by considering the practices of online games, such as *World of Warcraft,* where players volunteer, are highly motivated, and they actively participate.

Motivation has been one of the core concepts in research examining the learning potential of MMOGs. In many cases, the immersion of the players, the enthusiasm, the fun, the pleasure, and the sense of loss of time have been compared with Csikszentmihalyi's *sense of flow* (Bell et al. 2010; Burgess and Ice 2011). Ryan and Deci's *Self Determination Theory* has also been proposed as a framework for the study of motivation in games in relation to learning (Rigby and Przybylski 2009). The affective aspect of the games seems to be linked to positive learning outcomes through the motivation for engagement with the subject domain, the sense of self-efficacy, the positive attitude, and the emotional engagement (Mercedes and Rodrigo 2010; O'Neil et al. 2005).

Previous studies have shown that the main motives of MMOG players are relevant to: (a) the gaming aspect (that is, the elements of the game) and (b) the social aspect (that is, the interactions among players; Bartle 1996). Further research identified the sociability within the environment, the competition, success in game tasks, achievements and rewards, and the exploration of the game world as the main player motives (Dickey 2007; Williams et al. 2008; Yee 2006a). In fact, individual motivations for participation seem to also predict the progression in MMOGs. Progression of an MMOG player is better predicted by teamwork, cooperation, discovery, and guild affiliation. Players who are motivated by discovery and cooperation, and have also joined a game group, achieve higher rankings faster than players only motivated by advancement and the mechanics of the game (Billieux et al. 2013).

More specifically, the motivating aspect of MMOGs emerges from elements relevant to the design of the game, the narrative and story, the preferences and expectations of the players, and the social interactions and networks. Such elements are, for instance, the dynamic images, the challenges and the clear goals, the fantasy, the curiosity, the direct feedback to the player, the personalization of the player avatars, the flexibility and the freedom and control allowed to the player, the interactions with others, friendships and social ties, and the incremental progress corresponding to the level of the player (Ang and Rao 2008; Ducheneaut et al. 2006; Habgood 2005; Malone and Lepper 1987). It seems, therefore, that motivation and engagement in MMOGs rely on a complex matrix of elements involving both the representation and the interaction with the game environment and tasks, and also the social aspect of the game world and the collaborative or competitive interactions with others.

4.1 Networks, Groups, and Interactions

Meaningful interactions among the participants are a critical component of both MOOCs and MMOGs, considering particularly the massive number of participants they both attract. Progress and exploration of the content in MMOGs also involve participation in group tasks. Players have to join a group (e.g., guilds, clans, fellowships, enterprises) for progressing and coping with the heavily competitive aspect of the environment. Players form groups within the game environment, but they also constitute the broader community of the game, within and beyond the game environment.

MMOGs have been described as “designed civilizations,” “digital nations,” and spaces of complex social and communicative interactions, providing valuable insights for understanding practices and processes in distributed, computer-mediated communities (Kolo and Baur 2004; Squire 2006; Steinkuehler 2004a). They constitute a fascinating example of the dynamics of self-organized and self-coordinating online groups (Ducheneaut et al. 2007). Players form groups and communities; exhibit social practices; develop shared values and the “ethos” of the game; and they learn, understand, and participate in *communities of practice* (Carr and Oliver 2009; Nardi et al. 2007; Oliver and Carr 2009; Shaffer et al. 2005).

The groups constitute the fundamental units of analysis for the examination of social and instrumental interactions in MMOGs (Ducheneaut and Moore 2004a; Manninen 2003). They have been described as a distinct functional unit, a unit of governance in the economic and social system of the game (Kucklich 2009). The organization, the coordination, the goals, and the orientation of the groups depend, to a large extent, on the players themselves, since the environment provides limited tools for their management and operation. There is, consequently, a wide spectrum of different group types of different sizes, goals, and orientations, ranging from the less structured and more social “tree-house” groups to the more disciplined and structured “barracks” (Williams et al. 2006). Being a part of a group is, in any case, important both for the social aspect of the gaming experience and for attaining the game objectives.

Research on MMOG groups has identified a number of factors that contribute to the effectiveness and efficiency of groups. Such factors include the active participation of the members in group activities, cooperation, the quality of communication and the trust among the members, effective leadership and group coordination, the social and affective aspect of the group, the social relations among the members, members with a variety of different and complementary skills, the interdependence of the members and the linking of the individuals' goals with the goals of the group, and the cohesion and the sense that the group can support the attainment of the objectives of the members (Ho and Huang 2009; Lisk et al. 2012; Malone 2009; Pisan 2007). In fact, the social aspect of the group has been particularly emphasized. Groups with stronger social ties and objectives are more likely to be cohesive and effective in game tasks (Chen 2008; Pisan 2007).

Beyond the practices and the self-organization and coordination of the players, specific design elements have also been described for the support of the relations and the interactions among the players. Such elements refer to the support of the "*social architectures*" and social presence of the players: tools for the awareness of others, complementarity and interdependency of players, tasks and conflicts requiring teamwork and collaboration, severe penalties for failure, virtual spaces for social interactions, easy navigation in the virtual space, and a variety of communication tools for the support and sustainment of player relations. Severe penalties such as the death of the player avatar, for instance, may invoke moral dilemmas to the players and intensify their social interactions (Carter et al. 2013). These elements seem to improve group effectiveness, success in game tasks and problem solving, social and instrumental interactions, communication and collaboration, emotional engagement, solidarity, altruism, teamwork, trust, and the sense of community (Halloran 2009; Koivisto 2003; Koster 2009; Ratan et al. 2010; Schell 2008, p. 359; Tang et al. 2008; Williams et al. 2007).

Learner networks, sub-networks, communities of practice groups, and the self-organization of learners also constitute core concepts for MOOCs (Bell 2010; Cormier and Siemens 2010; Downes 2007). MOOCs, and particularly cMOOCs, rely on the active participation, the interactions of the learners, the development and sharing of new educational materials, and the critical role of peers in the network of learners. Yet, a large percentage of learners are, as previously discussed, mainly passive consumers of content, and reluctant to interact with others and create and share materials (Kop and Carroll 2011; Kop and Fournier 2011). Participation may be open to anyone but not all learners connect with each other (Chamberlin and Parish 2011).

This deficit in connectedness and active participation in knowledge sharing within online learning communities has been attributed to individual factors such as personality traits (e.g., trendsetting and pro-social values; Jadin et al. 2013) and personal learning style, as well as situational factors. These latter factors involve the security, confidence, and trust inspired by the environment, the interface design, the functionality, the tools for supporting communication and social presence, the fostering of a participatory and group culture, and the massive number of participants (Chamberlin and Parish 2011; Koutropoulos and Hogue 2012; Mackness et al. 2010). New learners need time to develop reciprocal relationships, to determine their audience and core community, as well as to realize mutual relationships within the community (Deng and Tavares 2013; Waite et al. 2013).

4.2 Structure, Freedom, and Control

One of the main challenges identified in MOOCs is the frustration of learners, particularly the novice, when confronted with the huge volume and the distributed nature of the course materials. Although the concept of "course" raises expectations for structure and guidance (Mackness et al. 2010), MOOC environments have been characterized as "chaotic" (Waard 2011). Learning in a distributed environment, particularly in the case of cMOOCs, requires self-regulated learning skill sets, often lacking in learners comfortable with traditional methods of teaching. New participants feel overwhelmed by technical issues, multiple communication and content channels, and a perceived need to multitask; they may easily get lost and have difficulties planning their learning route and navigating in the environment (Chamberlin and Parish 2011; Koutropoulos and Hogue 2012; Waite et al. 2013).

The example of online games can be referenced at this point (Morris and Stommel 2012). Games are not about absolute freedom of the player, but they rather situate the player in a specific framework and a structure within the boundaries of which they can improvise and experiment. Although in MMOGs the players are situated within a world where they can select their own path and experience the world in different ways based on their preferences, a certain degree of guidance and linear progression is integrated. Players may engage in player versus player (PvP) or player versus environment (PvE) content, or they can instead explore the environment and socialize; they may follow the main quest lines or they may focus more on side quests.

MMOGs seem to integrate a basic linear structure within a nonlinear world experience, involving short-term and long-term goals, and simple or complex tasks. The players are guided by, but not confined to, a series of different quests, simple at the beginning and more complex as they level up. Participation is voluntary and the players feel free to explore and engage with the content in any way they want. The rewards for the quests and the progression in the game are often motivating enough for the players to engage with them and reach higher levels of this progress path. There usually is, nevertheless, a core line of progression where the players have to incrementally build up their skills through problem-solving and game tasks.

A fundamental structure and progress path does not, though, imply simplicity, rather quite the opposite. In the case of MMOGs, complexity and depth of play are reported as some of the most critical elements of the gaming experience (Steinkuehler 2004b). Players are situated within a complex and dynamic system involving interactions with others, interactions with the virtual world, and access to distributed sources and resources; they will have to manage these aspects effectively in order to learn the game and play it. Research in online learning has further indicated that by giving to the learners control of their interactions and by providing incentives of reflection, learning outcomes are enhanced (Means et al. 2010).

Beyond the quests and tasks, the interactivity in games allows the integration of a *procedural rhetoric* (Bogost 2007). The arguments, messages, and abstract concepts are conveyed to the player though the rules and affordances, and the interaction of the player with the game environment. On the other end, they seem to further allow the players to be cocreators of the meaning of the game and the game experience, through their actions and their political, cultural, and ethical contexts (Sicart 2011). Players experiment in a simulated world, confined by the rules and affordances of the game, while at the same time the game experience is negotiated through the personal experiences and values of the individuals and through their communication and interactions with others.

4.3 Assessment of Learning

The assessment of learning constitutes one of the main challenges identified for MOOCs (Cormier and Siemens 2010). In many cases, MOOCs rely on methods such as automated quizzes, automated essay grading, network-based grading, portfolio-based assessment, peer assessment of student essays, or no assessment at all (Downes 2013). Learning without assessment though may not be appropriate (Levy 2011), peer assessment is not yet as reliable and accurate as assessment by an expert (Piech et al. 2013), and most of the remaining methods present risks and limitations, particularly for courses in humanities (Downes 2013).

In MMOGs, assessment of the player progress and the skills acquired is seamless in the gaming experience. There are no specific learning goals that have to be attained, but rather the acquisition of knowledge, skills, and expertise is a means for solving in-game problems and progressing in the environment. Players are presented with specific problems to be solved. In many cases, these problems may be solved with multiple different approaches. The players are free to acquire the relevant knowledge and skills through trial and error, practice, access to external resources, such as websites, or through their interactions with the player community. The acquired skills and knowledge are further applied and tested on the specific problems or tasks. Positive motivation techniques are also implemented, such as rewards, experience points, and explicit indications of the player progress.

Expertise in MMOGs, though, has been linked to more than efficiency and effectiveness in game tasks. Expert players also demonstrate social, resources management, and problem-solving skills (Huffaker et al. 2009; McCreery et al. 2011; Song et al. 2008; Voulgari and Komis 2013; Wang et al. 2009). Expert players are efficient in game tasks, but they have also developed a social capital, they engage in social activities, they act as mentors for other players, and they have gained the recognition of their peers. Acquisition and assessment of expertise in MMOGs are embedded in the gaming experience and also involve the social context and skills of the players.

5 Discussion and Conclusions

Based on the discussion of research in the fields of MOOCs and MMOGs, some common aspects have been identified that could be useful to the design of MOOCs. Commercial MMOGs, although not explicitly aiming at attaining learning outcomes, involve the engagement and management of massive numbers of people (with different backgrounds, motives, and preferences), the accomplishment of goals, the acquisition of expertise, and the emergence of a highly communicative and interactional space. Practices identified in MMOGs could inform the design of MOOCs, particularly in areas such as the engagement, the management, interactions and coordination of diverse learners, the support of the learning processes, the assessment of the learning outcomes, and the development of the learning materials.

Learner guidance: It seems that MOOC learners could benefit from a central structure as a reference point throughout their interaction with the course. MOOCs could integrate specified frameworks for guiding the learners through the learning activities. Such frameworks may involve sequences of well-defined tasks, activities and goals for the learners, as well as appropriate assessment activities. The educators also play a critical role and can act "as the glue of a course," through, for instance, daily reminders and synchronous activities (Chamberlin and Parish 2011; Cormier and Siemens 2010; Levy 2011; Waard 2011). Novice MOOC learners, in particular, require some guidance, much like the tutorials and guided navigation for new players in MMOGs, until they build up the necessary skills.

Groups and networks of people: Learning and interacting in vast networks of people may be a particularly daunting task, especially for new MOOCs learners. Management may be facilitated by the formation of smaller groups of people. In fact, there are indications that groups and network clustering are more efficient for the diffusion of behaviors than random networks, and they also support higher levels of engagement in this behavior through social reinforcement and social signals within the cluster (Centola 2010). Groups with a high degree of cohesion may be more effective for the development of a common knowledge space and the emergence of collaborative learning (Garrison et al. 1999). Group cohesion refers mainly to the forces that keep the group together, the links between group and members: the sense that they are part of a group, the commitment, and the motives. The social links emerging in the group, the common goals, and the interdependence of individual and group goals may be conducive to increased levels of trust (Korsgaard et al. 2010; Ratan et al. 2010).

Interactions should certainly not be limited in these groups. Joint activities of groups, much like the "alliances" in MMOGs, could bring together and strengthen the links among different groups for the accomplishment of common objectives. In addition, techniques for reducing phenomena such as *groupthink, conformity,* and group *polarization* could be considered for emphasizing the importance of individual thinking and supporting the accommodation of divergent perspectives and ideas (Asch 1955; Janis 1972, p. 8). MMOGs bring together heterogeneous groups of people, people from different cultural and social backgrounds, and provide the potential for the players to acquire a diverse social capital (Ducheneaut and Moore

2004b). Similarly, MOOCs attract the interest of learners from different cultural, political, and educational backgrounds providing a unique opportunity for constructive discourse and the discussion of different perspectives of a topic. The challenge at this point lies in the fostering of constructive communication and interactions among these differing groups of learners through, for instance, appropriate communication and interaction tools, rules of conduct, constructive feedback to the players, and shared goals.

Motivation and *engagement* of a wide range and a massive number of learners is a particularly complex task. In MMOGs, intrinsic motivation is triggered by the design of the environment, and also by the social environment and the sociability among players. Although MMOGs can rely upon tools lacking in MOOCs, such as the fantasy, the narrative, and the graphic representation of the virtual world, MOOCs can build upon the sociability and achievement axes for strengthening commitment and engagement with the content by integrating elements such as tasks triggering curiosity, competition, and cooperation among players, rewards, and recognition of individual achievement.

Beyond the initial motivation for participation though, sustaining commitment presents additional challenges. MMOG players may continue playing the game, even after having reached the higher levels of achievement, and they may even refer to it more as an obligation rather than as fun. MMOGs are succeeding at "blurring the boundaries between work and play" (Yee 2006b). Factors sustaining the commitment of the players to the game seem to be the *operant conditioning* and the *positive reinforcement* of rewards and achievements, the sense of obligation for completing tasks, particularly long-term tasks such as training of a specific skill or specialization of the player avatar, as well as the sense of obligation to the group, and also the personal relations and friendships evolved. Both the mechanics of the environment and the social settings are valid foundations for building up engagement and commitment.

Although MOOCs have raised a debate with respect to their implications on higher education policies and practices (e.g., Bogost et al. 2013), in this book chapter we mainly focused on MOOCs as learning tools and their interconnections with MMOGs. MOOCs provide a unique and valuable opportunity for anyone to access learning material and a learning community, which would otherwise be impossible to access. The rapid ascent of MOOCs has triggered research on the instructional and technological design so as to optimize the learning experience and outcomes. Our study attempted to discuss relevant challenges and view them from the perspective of a seemingly different environment, the MMOGs, which, nevertheless, had to cope with equivalent challenges.

MOOCs as learning tools are situated in the context of online learning, and can certainly draw from the large body of relevant research on online learning and computer-supported collaborative learning over the past decades; the additional challenges involve the massive numbers of people accessing the course, the networks of learners emerging, the potential triggered by the distributed content and sources of information, and the vast volumes of learner data gathered. Our study, nevertheless, presents some areas of intersection of MOOCs and MMOGs and addresses perspectives that may be considered for the instructional design of MOOCs.

References

Ang, C. S., & Radha Krishna Rao, G. S. V. (2008). Computer game theories for designing motivating educational software: A survey study. *International Journal on e-Learning, 7*(2), 181–199.

Ang, C. S., & Zaphiris, P. (2008). Social learning in MMOG: An activity theoretical perspective. *Interactive Technology and Smart Education, 5*(2), 84–102.

Asch, S. E. (1955). Opinions and social pressure. *Scientific American, 193*(5), 31–35.

Barron, B. (2003). When smart groups fail. *Journal of the Learning Sciences, 12*(3), 307–359.

Bartle, R. A. (1996). Hearts, clubs, diamonds, spades: Players who suit MUDs. *Journal of MUD Research, 1*(1), 5–34.

Bell, F. (2010). Network theories for technology-enabled learning and social change: Connectivism and actor network theory. In L. Dirckinck-Holmfeld, V. Hodgson, C. Jones, M. de Laat, D. McConnell, & T. Ryberg (Eds.), *Proceedings of the 7th International Conference on Networked Learning 2010* (pp. 526–533). Lancaster: Lancaster University.

Bell, M. W., Smith-Robbins, S., & Withnail, G. (2010). This is not a game–social virtual worlds,
fun, and learning. In A. Peachey, J. Gillen, D. Livingstone, & S. Smith-Robbins (Eds.), *Researching Learning in Virtual Worlds*. Springer, London, pp 177–191.

Billieux, J., Van der Linden, M., Achab, S., Khazaal, Y., Paraskevopoulos, L., Zullino, D., & Thorens, G. (2013). Why do you play world of warcraft? An in-depth exploration of self-reported motivations to play online and in-game behaviours in the virtual world of Azeroth. *Computers in Human Behavior, 29*(1), 103–109.

Bogost, I. (2007). *Persuasive games: The expressive power of videogames*. Cambridge: The MIT Press.

Bogost, I., Schroeder, R., Davidson, C. N., & Filreis, A. (2013). MOOCs and the future of the humanities: A roundtable. Los Angeles review of books. http://lareviewofbooks.org/essay/moocs-and-the-future-of-the-humanities-a-roundtable-part-1. Accessed 20 Sept 2103.

Burgess, M. L., & Ice, P. (2011). Optimal experience in virtual environments among college level developmental readers. *Journal of Educational Computing Research, 44*(4), 429–451.

Carr, D., & Oliver, M. (2009). Tanks, chauffeurs and backseat drivers: competence in MMORPGs. *Eludamos. Journal for Computer Game Culture, 3*(1), 43–53.

Carter, M., Gibbs, M., & Wadley, G. (2013). *Death and dying in DayZ*. In Proceedings of the 9th Australasian Conference on Interactive Entertainment: Matters of Life and Death (IE '13), Melbourne, VIC, Australia, 30 September- 01 October 2013. ACM, New York, NY, USA, p 22.

Centola, D. (2010). The spread of behavior in an online social network experiment. *Science, 329*(5996), 1194–1197.

Chamberlin, L., & Parish, T. (2011). MOOCs: Massive open online courses or massive and often obtuse courses? *eLearn, 8*(8), 1.

Chen, M. G. (2008). Communication, coordination, and camaraderie in world of warcraft. *Games and Culture, 4*(1), 47–73.

Cormier, D., & Siemens, G. (2010). The open course: Through the open door-open courses as research, learning, and engagement. *Educause Review, 45*(4), 30–39.

Deng, L., & Tavares, N. J. (2013). From moodle to facebook: Exploring students' motivation and experiences in online communities. *Computers & Education, 68,* 167–176.

Dickey, M. D. (2007). Game design and learning: A conjectural analysis of how massively multiple online role-playing games (MMORPGs) foster intrinsic motivation. *Educational Technology Research and Development, 55*(3), 253–273.

Downes, S. (2007). Groups vs networks: The class struggle continues. (Blog post). http://www.downes.ca/post/42521. Accessed 03 Sept 2013

Downes, S. (2009). Connectivist dynamics in communities. (Blog post). http://halfanhour.blogspot.gr/2009/02/connectivist-dynamics-in-communities.html. Accessed 01 Oct 2013.

Downes, S. (2013). Assessment in MOOCs. (Blog post). http://halfanhour.blogspot.gr/2013/05/assessment-in-moocs.html. Accessed 01 Oct 2013.

Ducheneaut, N. & Moore, R. J. (2004a) *Gaining more than experience points: Learning social behavior in multiplayer computer games*. Paper presented at the Conference on human factors in computing systems (CHI2004), Workshop on Social Learning Through Gaming, Vienna, Austria, 19 April 2004.

Ducheneaut, N., & Moore, R. J. (2004b). *The social side of gaming: A study of interaction patternsin a massively multiplayer online game*. In: Proceedings of the ACM Conference on Computer-Supported Cooperative Work (CSCW 2004), 6–10 November 2004. ACM, Chicago IL, USA, pp 360–369.

Ducheneaut, N., Moore, R. J., & Nickell, E. (2007). Virtual "third places": A case study of sociability in massively multiplayer games. *Computer Supported Cooperative Work, 16*(1), 129–166.

Ducheneaut, N., Yee, N., Nickell, E., & Moore, R. J. (2006). Building an MMO with mass appeal. A look at gameplay in world of warcraft. *Games and Culture, 1*(4), 281–317.

Egenfeldt-Nielsen, S. (2007). Third generation educational use of computer games. *Journal of Educational Multimedia and Hypermedia, 16*(3), 263–281.

Freitas, De S., & Griffiths, M. (2009). Massively multiplayer online role-play games for learning. In R. E. Ferdig (Ed.), *Handbook of research on effective electronic gaming in education* (pp. 51–66). Madison: IGI Global.

Galarneau, L. (2005). *Spontaneous communities of learning: Learning ecosystems in massively multiplayer online gaming environments*. In: Proceedings of DiGRA 2005 Conference: Changing Views—Worlds in Play, University of Vancouver, Vancouver, British Columbia, Canada, 16–20 June 2005. Available at: http://www.digra.org/digital-library/publications/spontaneous-communities-of-learning-learning-ecosystems-in-massively-multiplayer-online-gaming-environments/. Accessed 10 April 2014.

Garrison, D., Archer, T., & Anderson, W. (1999). Critical inquiry in a text-based environment: Computer conferencing in higher education. *The Internet and Higher Education, 2*(2–3), 87–105.

Habgood, M. P. J. (2005). Endogenous fantasy and learning in digital games. *Simulation & Gaming, 36*(4), 483–498.

Halloran, J. (2009). *It's talk, but not as we know it: Using VoIP to communicate in war games*. In Rebolledo-Mendez, G., Liarokapis, F., & de Freitas, S. (Eds.) Proceedings of Conference in Games and Virtual Worlds for Serious Applications 2009 (VS-GAMES '09), Coventry, UK, 23–24 March 2009. IEEE, Los Alamitos, CA, pp 133–140.

Ho, S. H., & Huang, C. H. (2009). Exploring success factors of video game communities in hierarchical linear modeling: The perspectives of members and leaders. *Computers in Human Behavior, 25*(3), 761–769.

Huffaker, D., Wang J., Treem, J., Ahmad, M. A., Fullerton, L., Williams, D., Poole, M. S., & Contractor, N. (2009). *The social behaviors of experts in massive multiplayer online role-playing games*. In: Proceedings of International Conference on Computational Science and Engineering, Vol. 4, Vancouver, BC, 29–31 August 2009. IEEE Computer Society Washington, DC, USA, pp 326–331.

Jadin, T., Gnambs, T., & Batinic, B. (2013). Personality traits and knowledge sharing in online communities. *Computers in Human Behavior, 29*(1), 210–216.

Janis, I. L. (1982). *Groupthink: Psychological studies of policy decisions and fiascoes*. Boston: Houghton Mifflin.

Jarvela, S., Jarvenoja, H., Veermans, M., & Ja, H. (2008). Understanding the dynamics of motivation in socially shared learning. *International Journal of Educational Research, 47*(2), 122–135.

Johnson, L., Adams Becker, S., Cummins, M., Freeman, A., Ifenthaler, D., & Vardaxis, N. (2013). *Technology outlook for Australian tertiary education 2013–2018: An NMC horizon project regional analysis*. Austin: The New Media Consortium.

Kafai, Y., & Peppler, K. A. (2011). Beyond small groups: New opportunities for research in computer-supported collective learning. In *Proceedings of the 9th Conference of Computer Supported Collaborative Learning*. Hong Kong: International Society of the Learning Sciences.

Kirschner, P., & Van Bruggen, J. (2004). Learning and understanding in virtual teams. *Cyberpsychology & behavior: The impact of the Internet, multimedia and virtual reality on behavior and society, 7*(2), 135–139.

Kizilcec, R. F., & Piech, C. (2013). Deconstructing disengagement: Analyzing learner subpopulations in massive open online courses. In: D. Suthers, K. Verbert, E. Duval, & X. Ochoa (Eds.), *Proceedings of the 3rd International Conference on Learning Analytics and Knowledge*. Leuven: ACM.

Koivisto, E. M. (2003). *Supporting communities in massively multiplayer online role-playing games by game design*. In Proceedings of 2003 DIGRA Conference: Level Up.

Kolo, C., & Baur, T. (2004). Living a virtual life: Social dynamics of online gaming. *Game Studies, 4*(1), 1–31.

Kop, R., & Carroll, F. (2011). Cloud computing and creativity: Learning on a massive open online course. *European Journal of Open, Distance and E-learning. Special Issue on Creativity and OER*. http://www.eurodl.org/index.php?article=457. Accessed 25 Nov 2013

Kop, R., & Fournier, H. (2011). New dimensions to self-directed learning in an open networked learning environment. *International Journal of Self-Directed Learning, 7*(2), 1–20.

Korsgaard, M. A., Picot, A., Wigand, R. T., Welpe, I. M., & Assmann, J. J. (2010). Cooperation, coordination, and trust in virtual teams: Insights from virtual games. In W. S. Bainbridge (Ed.), *Online worlds: Convergence of the real and the virtual* , Springer, London, pp 253–264.

Koster, R. (2009). Ways to make your virtual space more social (Blog post). http://www.raphkoster.com/2009/01/28/ways-to-make-your-virtual-space-more-social/#more-2486. Accessed 25 November 2013.

Koutropoulos, A., & Hogue, R. (2012). How to succeed in a MOOC-massive online open course. In: *Learning Solutions Magazine*, 8 October 2012. Available at: http://www.learningsolutionsmag.com/articles/1023/how-to-succeed-in-a-massive-online-open-course-mooc. Accessed 31 Aug 2013.

Kreijns, K., & Kirschner, P. A. (2002). The sociability of computer-supported collaborative learning environments. *Educational Technology & Society, 5*(1), 8–22.

Kucklich, J. R. (2009). Virtual worlds and their discontents: Precarious sovereignty, governmentality, and the ideology of play. *Games and Culture, 4*(4), 340–352.

Levy, D. (2011). *Lessons learned from participating in a connectivist massive online open course (MOOC)*. Emerging Technologies for Online Learning Symposium, the Sloan Consortium, San Jose, pp. 31–36.

Lisk, T. C., Kaplancali, U. T., & Riggio, R. E. (2012). Leadership in multiplayer online gaming environments. *Simulation & Gaming,* 43(1), 133–149.

Mackness, J., Mak, S., & Williams, R. (2010). The ideals and reality of participating in a MOOC. In: L. Dirckinck-holmfeld, V. Hodgson, C. Jones, M. de Laat, D. McConnell, & T. Ryberg (Eds.), *Proceedings of the Seventh International Conference on Networked Learing* (pp. 266–275). Lancester: University of Lancaster

Malone, K. L. (2009). Dragon kill points: The economics of power gamers. *Games and Culture, 4*(3), 296–316.

Malone, T. W., & Lepper, M. R. (1987). Making learning fun: A taxonomy of intrinsic motivations for learning. *Aptitude Learning and Instruction, 3*(3), 223–253.

Manninen, T. (2003). Interaction forms and communicative actions in multiplayer games. *Game Studies, 3*(1), 1–12.

McCreery, M. P., Schrader, P. G., & Krach, S. K. (2011). Navigating massively multiplayer online games: Evaluating 21st century skills for learning within virtual environments. *Journal of Educational Computing Research, 44*(4), 473–493.

Means, B., Toyama, Y., Murphy, R., Bakia, M., & Jones, K. (2010). *Evaluation of evidence-based practices in online learning. A meta-analysis and review of online learning studies*. Washington, D.C.: U.S. Department of Education, Office of Planning, Evaluation, and Policy Development.

Mercedes, M., & Rodrigo, T. (2010). Dynamics of student cognitive-affective transitions during a mathematics game. *Simulation & Gaming, 42*(1), 85–99.

Morris, S. M., & Stommel, J. (2012). Udacity and online pedagogy: Players, learners, objects. *Hybrid Pedagogy. A Digital Journal of Learning, Teaching, and Technology*.

Murdoch, D. (2013). Of MOOCs and MMORPGs and how we learn. (Blog post). http://medium.com/the-transformation-of-education/666ebb07a6c2. Accessed 10 Sept 2013.

Nardi, B. A., Ly, S., & Harris, J. (2007). Learning conversations in world of warcraft. In *2007 40th Annual Hawaii International Conference on System Sciences (HICSS'07)* (pp. 79–79). IEEE

O'Neil, H., Wainess, R., Baker, E., & Routledge, P. (2005). Classification of learning outcomes: Evidence from the computer games literature. *Curriculum Journal, 16*(4), 455–474.

Oliver, M., & Carr, D. (2009). Learning in virtual worlds: Using communities of practice to explain how people learn from play. *British Journal of Educational Technology, 40*(3), 444–457.

Piech, C., Huang, J., Chen, Z., Do, C., Ng, A., & Koller, D. (2013). *Tuned models of peer assessment in MOOCs*. In Proceedings of the 6th International Conference on Educational Data Mining. Memphis, Tennessee.

Pisan, Y. (2007). *My guild, my people: Role of guilds in massively multiplayer online games*. In Proceedings of the 4th Australasian conference on Interactive entertainment (Vol. 305), Melbourne, RMIT University.

Ratan, R., Chung, J., Shen, C., Poole, M., & Williams, D. (2010). Schmoozing and smiting: Trust, social institutions and communication patterns in an MMOG. *Journal of Computer Mediated Communication,* 16(1), 93–114.

Rigby, C. S., & Przybylski, A. K. (2009). Virtual worlds and the learner hero: How today's video games can inform tomorrow's digital learning environments. *Theory and Research in Education, 7*(2), 214–223.

Rodriguez, C. O. (2012). MOOCs and the AI-Stanford like courses: Two successful and distinct course. *European Journal of Open, Distance and E-Learning*. http://www.eurodl.org/materials/contrib/2012/Rodriguez.htm. Accessed 12 Sept 2013

Romero, M. (2013). Game based learning MOOC. Promoting entrepreneurship education. *Elearning Papers, Special Edition MOOCs and Beyond*, *33*(May). http://openeducationeuropa.eu/en/article/Game-Based-Learning-MOOC.-Promoting-Entrepreneurship-Education. Accessed 12 Sept 2013

Schell, J. (2008). *The art of game design: A book of lenses*. Burlington: Elsevier.

Schrader, P. G., & McCreery, M. (2008). The acquisition of skill and expertise in massively multiplayer online games. *Educational Technology Research and Development, 56*(5–6), 557–574.

Sfard, A. (1998). On two metaphors for learning and the dangers of choosing just one. *Educational Researcher, 27*(2), 4–13.

Shaffer, D. W., Squire, K. R., Gee, J. P., & Halverson, R. (2005). Video games and the future of learning. *Phi Delta Kappan, 87*(2), 104–111.

Sicart, M. (2011). Against procedurality. Game Studies, *The International Journal of Computer Game Research,11*(3). Available at: http://gamestudies.org/1103/articles/sicart_ap. Accessed 29 Jul 2013.

Siemens, G. (2005). Connectivism: A learning theory for the digital age. *Journal of Instructional Technology and Distance Learning, 2*(1), 3–10.

Song, S., Kim, M., & Song, D. H. (2008). *The cognitive processing mechanism for the players' rule in MMO game*. In Proceedings of 2008 IEEE/WIC/ACM International Conference on Web Intelligence and Intelligent Agent Technology (pp. 252–255). IEEE.

Squire, K. (2006). From content to context: Videogames as designed experience. *Educational Researcher, 35*(8), 19–29.

Steinkuehler, C. A. (2004a). *A discourse analysis of MMOG talk*. In Proceedings of the Other Players Conference, Copenhagen, IT University of Copenhagen.

Steinkuehler, C. A. (2004b). Learning in massively multiplayer online games. In Y. B. Kafai, W. A. Sandoval, N. Enyedy, A. S. Nixon, & F. Herrera (Eds.), *Proceedings of the 6th international conference on learning sciences* (pp. 521–528). Mahwah: Erlbaum.

Strijbos, J. W., Martens, R. L., & Jochems, W. M. G. (2004). Designing for interaction: Six steps to designing computer-supported group-based learning. *Computers & Education, 42,* 403–424.

Tang, Y., Man C. Y., Hang, C. P., Cheuk, L. S., Kwong, C. W., Chi, Y. C., Fai, H. K., & Kam, S. (2008). A study of interaction patterns and awareness design elements in a massively multiplayer online game. *International Journal of Computer Games Technology, 2008*(5), 1–8.

Van Den Bossche, P., Gijselaers, W. H., Segers, M., & Kirschner, P. A. (2006). Social and cognitive factors driving teamwork in collaborative learning environments: Team learning beliefs and behaviors. *Small Group Research, 37*(5), 490–521.

Voulgari, I., & Komis, V. (2013). *Players' perceptions on the concept of the "good player" in MMOGs*. Foundations of Digital Games Conference 2013 (pp. 79–85). Chania, Greece.

Voulgari, I., Komis, V., & Sampson, D. G. (2013). Learning outcomes and processes in massively multiplayer online games: Exploring the perceptions of players. *Educational Technology Research & Development, 62,* 245–270. (Advance online publication).

Waard, I. de. (2011). Explore a new learning frontier: MOOCs. In: *Learning Solutions Magazine*, 25 July 2011. Available at: http://www.learningsolutionsmag.com/articles/721/explore-a-new-learning-frontier-moocs. Accessed 31 Aug 2013.

Waite, M., Mackness, J., & Roberts, G. (2013). Liminal participants and skilled orienteers: Learner participation in a MOOC for new lecturers. *MERLOT Journal of Online Learning and Teaching, Special Issue on Massive Open Online Courses, 9*(2), 200–215.

Wang, J., Huffaker, D., Treem, J., Fullerton, L., Ahmad, M. A., Williams, D., Poole, M. S., & Contractor, N. (2009). Focused on the prize: Characteristics of experts in virtual worlds. In: *First Monday*, 16(8). Available at: http://firstmonday.org/ojs/index.php/fm/article/view/3672/3028. Accessed 13 April 2014.

Williams, D., Caplan, S., & Xiong, L. (2007). Can you hear me now? The impact of voice in an online gaming community. *Human Communication Research, 33*(4), 427–449.

Williams, D., Ducheneaut, N., Xiong, L., Zhang, Y., Yee, N., & Nickell, E. (2006). From tree house to barracks: The social life of guilds in world of warcraft. *Games and Culture, 1*(4), 338–361.

Williams, D., Yee, N., & Caplan, S. E. (2008). Who plays, how much, and why? Debunking the stereotypical gamer profile. *Journal of Computer-Mediated Communication, 13*(4), 993–1018.

Williamson, B., & Facer, K. (2004). More than "just a game": The implications for schools of children's computer games communities. *Education, Communication & Information, 4*(2–3), 255–270.

Yee, N. (2006a). Motivations for play in online games. *Cyberpsychology & behavior: the impact of the Internet, multimedia and virtual reality on behavior and society, 9*(6), 772–775.

Yee, N. (2006b). The labor of fun: How video games blur the boundaries of work and play. *Games and Culture, 1*(1), 68–71.

Chapter 5
Supporting Open Access to Teaching and Learning of People with Disabilities

Panagiotis Zervas, Vassilis Kardaras, Silvia Baldiris, Jorge Bacca, Cecilia Avila, Yurgos Politis, Deveril, Jutta Treviranus, Ramon Fabregat, Lizbeth Goodman and Demetrios G. Sampson

1 Introduction

Inclusive learning has been the focus of numerous efforts worldwide (Florian and Linklater 2010). Therefore, several frameworks have been developed aiming to support the provision of flexible or individualized learning experiences that address inclusion such as differentiated learning (Tomlinson and McTighe 2006) and universal design for learning (Rose and Meyer 2002). These frameworks recognize the broad diversity of learners with respect to ability, language, culture, gender, age, and other forms of human difference and they provide specific learning design principles to ensure accessibility of all learner types to the learning environment or education delivery.

In the field of technology-enhanced learning (TeL), accessibility has been recognized as a key design consideration for TeL systems ensuring that learners with diverse needs and preferences (such as learners with disabilities) can access tech-

P. Zervas (✉)
Department of Digital Systems, University of Piraeus,
150 Androutsou Odyssea Street, GR-18532 Piraeus, Greece

Information Technologies Institute, Centre for Research and Technology—Hellas,
Thessaloniki, Greece
e-mail: pzervas@iti.gr

D. G. Sampson
Department of Digital Systems, University of Piraeus,
150 Androutsou Odyssea Street, GR-18532 Piraeus, Greece
e-mail: sampson@unipi.gr

Information Technologies Institute, Centre for Research and Technology—Hellas,
Thessaloniki, Greece
e-mail: sampson@iti.gr

V. Kardaras
Department of Digital Systems, University of Piraeus,
150 Androutsou Odyssea Street, GR-18532 Piraeus, Greece
e-mail: vasiliskardaras@gmail.com

D. G. Sampson et al. (eds.), *Digital Systems for Open Access to Formal and Informal Learning*,
DOI 10.1007/978-3-319-02264-2_5,

nology-supported resources, services, and experiences in general (Seale and Cooper 2010). There have been many generic definitions of the term accessibility, but IMS Global Learning Consortium (2004) offers an education-specific definition of both disability and accessibility: *"The term disability is defined as a mismatch between learner's needs and the education offered. It is therefore not a personal trait, but an artifact of the relationship between the learner and the learning environment or education delivery. Accessibility is the ability of the learning environment to adjust to the needs and preferences of each learner. Accessibility is determined by the flexibility of the education environment (with respect to presentation, control methods, access modality and learner supports) and the availability of adequate alternative-but-equivalent content and activities."* This definition has been adopted by the International Organization for Standardization/International Electrotechnical Commission (ISO/IEC) Standard 24751 "Individualized Adaptability and Accessibility in e-Learning, Education and Training." ISO/IEC 24751 provides a common framework to describe and specify learner needs and preferences on the one hand and the corresponding description of the digital educational resources on the other. This enables individual learner preferences and needs to be matched with the appropriate user interface tools and digital educational resources (ISO/IEC JTC1/SC36 2008a; ISO/IEC JTC1/SC36 2008b).

Within this context, several initiatives have emerged, such as the Inclusive Learning project, which aims to promote an inclusive learning culture and support teachers in designing, sharing, and delivering accessible educational resources in

S. Baldiris · J. Bacca · C. Avila · R. Fabregat
Institute of Informatics and applications, Universitat de Girona,
Campus de Montilivi, EPS. Edifici P4, Av. Lluis Santalo s/n, 17071 Girona, Spain
e-mail: baldiris@eia.udg.edu

J. Bacca
e-mail: jorge.bacca@udg.edu

C. Avila
e-mail: ceciliaagarzon@yahoo.com

R. Fabregat
e-mail: ramon.fabregat@udg.edu

Y. Politis · Deveril · L. Goodman
SMARTlab, School of Education, Roebuck Castle, University College Dublin (UCD),
Belfield, Dublin 4, Dublin, Ireland
e-mail: yurgos.politis@ucd.ie

Deveril
e-mail: dr.deveril@ucd.ie

L. Goodman
e-mail: Lizbeth@smatlab-ie.com

J. Treviranus
Inclusive Design Research Centre, OCAD University, 100 McCaul Street,
Toronto, ON M5T 1W1, Canada

Raising the Floor International, Geneva, Switzerland
e-mail: jtreviranus@ocadu.ca

the form of learning objects (LOs). To this end, the scope of this book chapter is to present an online educational portal, namely the Inclusive Learning Portal that aims to support open access to teaching and learning of people with disabilities. More specifically, the Inclusive Learning Portal architecture is presented, which contains a repository of accessible LOs, complementary services that enable easy development and delivery of accessible LOs, as well as teacher training opportunities in the use of these services.

The book chapter is structured as follows. Following this introduction, Sect. 2 describes the requirements of the Inclusive Learning Portal, based on which we compare existing portals in Sect. 3. Afterwards, Sect. 4 presents the conceptual architecture of the Inclusive Learning Portal and its main components, while Sect. 5 presents the implementation of the Inclusive Learning Portal. Finally, we discuss our main conclusions.

2 Requirements of the Inclusive Learning Portal

This section focuses on the first step of the development life cycle (Avison and Shah 1997), namely requirements analysis, by first setting a common terminology, identifying the main portal users, and afterwards discussing functional and nonfunctional requirements.

2.1 Terminology

The Inclusive Learning Portal aims to include accessible LOs organized in two aggregation levels, as follows:

- *Accessible educational resources* are typically digital materials such as video and audio lectures (podcasts), references and readings, and workbooks and textbooks, which conform to W3C Web Content Accessibility Guidelines 2.0 (W3C 2008).
- *Accessible training courses* are sequences of learning activities, which include accessible educational resources, tools, and services. They follow a specific pedagogical strategy, which is suitable for disabled people training, and they are conducted entirely online targeting specific educational objectives.

2.2 Users

The Inclusive Learning Portal identifies two main types of portal users, as follows:

- *Teachers of People with Disabilities:* They are the main recipients of the functionality offered by the Inclusive Learning Portal. They are able to create an account, which allows them to access the services offered by the portal. Teachers are able to search for accessible LOs, as well as create and upload their own

accessible LOs. They can also deliver accessible LOs (namely, training courses) to their disabled learners. Moreover, they can communicate with other teachers. Finally, they can engage in training opportunities toward enhancing their competences about inclusive design and accessibility.
- *Learners:* They use only a limited set of the Inclusive Learning Portal services. More specifically, they can enroll in accessible training courses offered by their teachers.

2.3 Functional Requirements

In this section, we present the main functionalities that are should be offered by the Inclusive Learning Portal, in order to allow its users to address their individual needs. These functionalities can be summarized below:

- *User profiling:* Teachers should be able to create their profile and access a dashboard with the activities that they have performed in the Inclusive Learning Portal.
- *Uploading accessible LOs:* Teachers should be able to upload and store accessible LOs to the Inclusive Learning Portal by describing them with appropriate educational metadata.
- *Authoring accessible LOs:* Teachers should be able to use authoring tools for developing accessible LOs in the form of accessible training courses.
- *Annotating accessible LOs:* Teachers should be able to rate, comment, tag, and bookmark accessible LOs. These annotations are expected to be used by other teachers for assessing the quality of the accessible LOs during searching
- *Searching accessible LOs:* Teachers should be able to search for accessible LOs across existing repositories either by using formal metadata added by the authors of these LOs, e.g., grade level, subject domain, disability type, etc. or by using social metadata added by the users of the LOs (namely, the teachers) such as social tags and ratings.
- *Delivering accessible LOs:* Teachers should be able to organize and deliver their own accessible training courses to their disabled learners. Learners should able also to enroll in these courses.
- *Communicating with users:* Proper tools should be made available to the teachers for communicating and collaborating with other colleagues in order to exchange ideas and best teaching practices.
- *Participating in training academies:* Users should have access to training academies that offer them training opportunities for enhancing their competences about inclusive learning and accessibility.

2.4 Nonfunctional Requirements

In addition to the previous requirements, there are also nonfunctional requirements that can influence the design of the Inclusive Learning Portal, as follows:

- *Scalability:* The Inclusive Learning Portal is expected to be used at European level. Therefore, it is clear that the underlying network, hardware and software infrastructure should have sufficient capacity to ensure high availability.
- *Application Programming Interface (API):* The Inclusive Learning Portal should be extensible and allow for the reuse of the LOs' metadata it harvests and stores. A search API should be provided in order for third parties to utilize the Inclusive Learning infrastructure.
- *Usability:* The Inclusive Learning Portal should deliver various tools (such as metadata authoring and course authoring tools) which should be intuitive and easy to use, in order to reduce the workload of teachers and keep them involved.
- *Privacy:* The Inclusive Learning Portal will store teachers' personal information. Therefore, the portal should protect any personal or private information belonging to the teachers. On the other hand, disabled learners' personal information will not be stored in the portal.
- *Accessibility:* Inclusive Learning Portal services that are used by disabled learners should be accessible to them. This means that these services should utilize Web accessibility standards such as W3C Web Content Accessibility Guidelines 2.0 and ISO/IEC 24751 Access for All Standard.

3 Related Work

In this section, we provide an overview of existing portal solutions that aim to support open access to teaching and learning of people with disabilities. Moreover, we compare the features of these portal with the functional requirements presented in Sect. 2. We have identified five existing portals, namely: (1) The TILE Portal that was developed in the framework of a nationally funded project in Canada referred to as "Inclusive Learning Exchange" (Nevile et al. 2005; Harrison and Treviranus 2003), (2) the EPKhas Portal, which has been developed by the School of Educational Studies of the University of Science in Malaysia (Lee 2010), (3) the TES-Connect Portal of the Times Educational Supplement Magazine, (4) the LALIDC Portal developed by Louisiana Low Incidence Disabilities Consortium in the USA, and (5) the KlasCement Portal, which is supported by the Flemish government and several educational partners in Belgium (Pynoo et al. 2011). Table 5.1 summarizes the features of the indentified portals.

As shown in Table 5.1, the main requirements that are supported by existing portal solutions are user profiling, uploading accessible LOs, annotating accessible LOs, searching accessible LOs, and communicating with users. On the other hand, there are several requirements that are not supported by existing federated infrastructures such as authoring accessible delivering accessible LOs and participating in training academies. As a result, it is evident that the Inclusive Learning Portal aims to advance existing solutions and offer an enhanced open-access online educational support to assist teaching and learning of people with disabilities.

Table 5.1 Comparing existing portals with Inclusive Learning Portal's functional requirements

Functional requirements	TILE[a]	EPKhas[b]	TESConnect[c]	LALIDC[d]	KlasCement[e]
User profiling	✕	✓	✓	✕	✓
Uploading accessible LOs	✓	✓	✓	✕	✓
Authoring accessible LOs	✕	✕	✕	✕	✕
Annotating accessible LOs	✕	✓	✓	✕	✓
Searching accessible LOs	✓	✓	✓	✓	✓
Delivering accessible LOs	✕	✕	✓	✕	✓
Communicating with users	✓	✕	✕	✓	✓
Participating in training academies	✕	✕	✕	✕	✕

(✓) requirement supported, (✕) not supported
[a] http://www.inclusivelearning.ca/
[b] http://epkhas.ses.usm.my/english-main
[c] http://www.tes.co.uk/sen-teaching-resources/
[d] http://lalidcrepository.org/
[e] http://www.klascement.be/leerzorg/alle/?set_language=4

4 The Inclusive Learning Portal Architecture

This section presents the Inclusive Learning Portal architecture that has been designed based on the functional requirements defined in Sect. 2.

4.1 Overview

The overall architecture of the Inclusive Learning Portal is presented in Fig. 5.1. As shown, at the lower level there are existing repositories with accessible LOs. The metadata of these repositories are harvested and stored to the Inclusive Learning Repository, which is located at the middle level of the architecture. Moreover, at the middle level of the architecture, there is the educational metadata harvester, which aims to harvest metadata that have been created by the authors of the LOs and they are stored in the external repositories.

At the upper level of the architecture, there is the Inclusive Learning Portal interface which includes (1) a searching mechanism for accessing the Inclusive Learning Repository; (2) collaboration tools, which facilitate teachers to communicate and collaborate with other teachers; (3) a metadata authoring tool adding metadata to accessible Los; and (4) an inclusive learning handbook, which provides the teachers with an easy guide to go through the principles of inclusive design and accessibility, as well as to understand the process of developing and sharing accessible LOs.

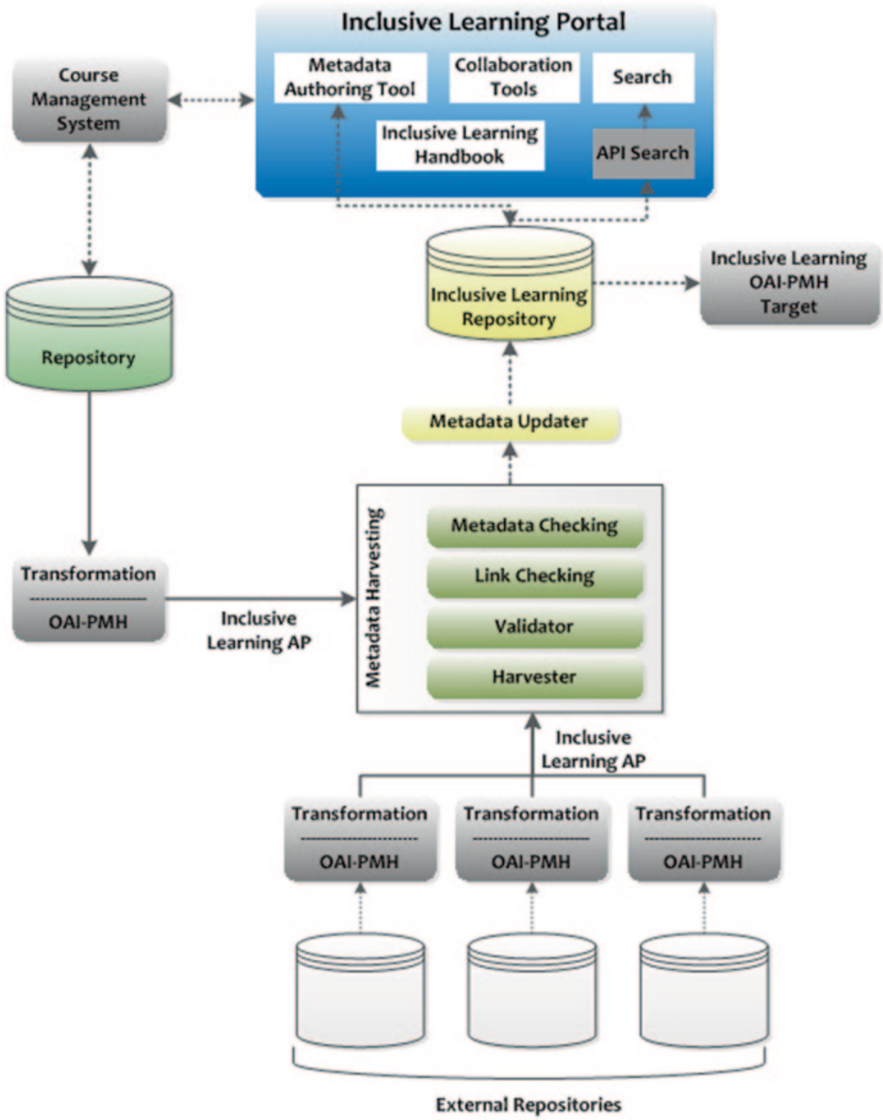


Fig. 5.1 The Inclusive Learning Portal architecture

Finally, there is also a course management system, where teachers can design and deliver accessible training courses to their disable learners. These courses are stored in a repository, which are also harvested and stored to the Inclusive Learning Repository and they can be reused by other teachers of the Inclusive Learning Portal.

The next section elaborates on the components of the architecture in more detail.

4.2 Components

External repositories include Learning Object Repositories (LORs) that have been developed in the framework of previous EU-funded or national-funded projects and the Inclusive Learning Portal aims to federate.

The *metadata harvester* collects educational metadata from the external repositories. It includes four subcomponents, which are the following:

- *Harvester:* It harvests metadata records provided by external repositories. In order to ensure interoperability of the harvesting process, the harvester has been based on open standards such as the Open Archives Initiative Protocol for Metadata Harvesting (OAI-PMH). Moreover, all metadata records from external repositories are transformed to Inclusive Learning metadata application profile (Inclusive Learning AP). Inclusive Learning AP is based on the IEEE Learning Object Metadata (IEEE LOM) standard (IEEE LTSC 2005) and it has been tailored specifically to support the classification of LOs based on their accessibility characteristics. Inclusive Learning AP is used to describe all LOs made available through the Inclusive Learning Portal. Apart from ensuring a unified way of describing LOs, it serves as basis for enriching incomplete metadata.
- *Validator:* It validates the metadata records that are harvested by the harvester, so as to ensure that they conform to the Inclusive Learning AP.
- *Link checking:* It is used in order to verify that the metadata record includes a valid URL to the respective LO of the external repository. If the URL does not work, then the metadata record is excluded from the harvesting process.
- *Metadata checking:* It performs a completeness check of the metadata records that are harvested based on the Inclusive Learning AP. If incomplete metadata records exist, then they are flagged, so as to be enriched in the future by appropriate Inclusive Learning Portal users.

The *Inclusive Learning Repository* aggregates the metadata of the LOs that are produced from the Inclusive Learning Portal and harvested from external repositories.

The *Inclusive Learning Portal* is the interface that is presented to the portal's users. It includes four main subcomponents, namely:

- *Search:* It facilitates teachers in searching for accessible LOs by following different approaches such as:
  - *Simple keyword search:* Using keywords and combinations, the teacher is able to search through the accessible LOs within the Inclusive Learning Portal. The keyword search uses the metadata that describe the accessible LOs, taking into account the metadata provided by external repositories as well as social tags provided by users.
  - *Facetted search:* The teacher is able to qualify the keyword search with several additional facets such as the external repositories in which to search, the language of the results, the LO type, the disability type, etc. When a value is selected for a facet, the interface dynamically changes and provides the numbers of results for each facet that match the selected criteria.

   – *Social tagging search:* The teacher is presented with the most popular tags contributed by the Inclusive Learning Portal's teachers, visualized by a tag cloud. A tag links to the respective accessible LO(s).
- *Collaboration Tools:* Enable teachers to easily communicate and collaborate with other teachers for sharing ideas, as well as best set-up. These tools include a forum, as well as a private messaging tool.
- *Metadata Authoring Tool:* Enables users to characterize their own accessible LOs with educational metadata (following the Inclusive Learning AP) and upload them to the Inclusive Learning Portal. This tool is also used by the Inclusive Learning Portal users to edit and enrich the metadata of accessible LOs that are harvested by the external repositories.
- *Inclusive Learning Handbook:* This subcomponent provides the teachers with specific learning design principles to ensure that teaching practices can accommodate all types of students. It also aims to assist teachers in developing engaging and motivating learning experiences for all learners, regardless of their special abilities and preferences. Finally, it provides guidelines for developing accessible LOs, as well as examples for restricting or eliminating nonaccessible elements, such as the use of extensive amounts of text, flash animations, and other nonaccessible design options.

The *course management system* enables teachers to design accessible training courses and deliver them to their disabled learners. These courses are also harvested and stored to the Inclusive Learning Repository and they can be reused by other teachers of the Inclusive Learning Portal. Moreover, through this course management system, teachers are able to participate in teacher training courses that will facilitate them in enhancing their competences in the process of designing and developing accessible LOs.

5 Implementation of the Inclusive Learning Portal

Based on the presented design, the Inclusive Learning Portal has been developed following an iterative and incremental approach. The home page of the Inclusive Learning Portal, at the time of writing,[1] is presented in Fig. 5.2.

The Inclusive Learning Portal[2] is built on Drupal.[3] Drupal is a widely used, open-source content management system, and content management framework based on PHP and MySQL that allows for high scalability. It is free and open source and is distributed under the GNU General Public License.

An important element of the Inclusive Learning Portal architecture is the Inclusive Learning AP. Inclusive Learning AP has been implemented in accordance

[1] November 2013.

[2] http://www.inclusive-learning.eu/.

[3] https://drupal.org/.

Fig. 5.2 The Inclusive Learning Portal home page

with the steps of the guidelines proposed by international organizations such as IMS Global Learning Consortium (IMS GLC) and European Committee for Standardization (CEN/ISSS) for developing IEEE LOM APs (Duval et al. 2006; IMS GLC 2005). The Inclusive Learning metadata harvester is implemented based on the ARIADNE architecture (Ternier et al. 2009), which is a standard-based architecture for harvesting LOs in an open and scalable way. The architecture supports the integration of LOs in multiple, distributed repository networks. In order to ensure that only Inclusive Learning AP compliant metadata records arrive in the harvested metadata store, the ARIADNE metadata validation service is used for checking records against the Inclusive Learning AP. This service builds on XML Schema (XSD), Schematron rules, and special purpose components to check for compliance. This is necessary because metadata instances that are harvested contain errors (e.g., empty fields, syntactic errors, etc.). Implementing the rules that are specified in the Inclusive Learning AP, the validation results are returned to the originating metadata repository to enable providers to correct the errors.

Another important element of the Inclusive Learning Portal architecture is the Inclusive Learning Handbook, which provides an easy guide for teachers on how to develop accessible LOs. The Inclusive Learning Handbook is built with Wordpress.[4] Wordpress is also an open-source content-management system based on PHP and MySQL and it is distributed under the GNU General Public License. This choice of implementation enables the Inclusive Learning Handbook to be modified in the future as new tools, methodologies, and technologies appear.

The course management system of the Inclusive Learning Portal is based on ATutor.[5] ATutor is an open-source accessible course management system developed by the Adaptive Technology Resource Centre of the University of Toronto. ATutor is built around IMS Access For All[6] specifications and it aims to allow access to all potential learners, including those with disabilities who may be accessing the system using assistive technologies.

Finally, the design and development of accessible training courses in ATutor is supported by TinyMCE.[7] TinyMCE is a web content-authoring tool, which provides a user-friendly interface and a set of functionalities that allow teachers to create web-based educational resources. TinyMCE has been adapted in order to provide with better support when teachers are developing accessible LOs, by following the W3C Web Content Accessibility Guidelines 2.0. Moreover, TinyMCE integrates a plug-in, which uses the AChecker[8] automatic validation results in order to present the teachers with a report of possible errors or warnings about the accessibility of the LOs that they are developing with TinyMCE.

6 Conclusions

The issue of accessibility in TeL is very important, so as to ensure that technology does not introduce more barriers to the inclusion of people with disabilities. To this end, several initiatives have emerged worldwide that aim to tackle accessibility considerations of technology-supported resources, services, and experiences in general. Thus, in this chapter, we presented the Inclusive Learning Portal, which aims to (1) support teachers in the process of developing, sharing, and delivering accessible LOs that can address the diversity of disabled learner needs and requirements and (2) provide teacher training opportunities for enhancing teachers' competences on inclusive learning and accessibility principles.

At the time of writing,[9] the Inclusive Learning Portal includes more than 4,000 accessible LOs for groups of learners with physical disabilities, namely people with visual and hearing impairments, as well as people with motor disabilities. The main target of the Inclusive Learning Portal is to create and sustain a network of teachers of people with disabilities, who will be developing and sharing their own accessible LOs used in training organizations around Europe.

---

[4] http://wordpress.org/.

[5] http://atutor.ca/.

[6] http://www.imsglobal.org/accessibility/.

[7] http://www.tinymce.com/.

[8] http://achecker.ca/checker/index.php.

[9] November 2013.

Acknowledgments The work presented in this chapter has been supported by the Inclusive Learning Project that is funded by the European Community under the Leonardo da Vinci (LdV) Sectoral Programme of the Lifelong Learning Programme (Contract No: 2012-1-ES1-LEO05-49449).

References

Avison, D. E., & Shah, H. U. (1997). *The information systems development life cycle: A first course in information systems.* New York: McGraw-Hill.

Duval, E., Smith, N., & Van Coillie, M. (2006). *Application profiles for learning*. In Proceedings of the 6th IEEE International Conference on Advanced Learning Technologies (ICALT 2006), Netherlands, pp. 242–246.

Florian, L., & Linklater, H. (2010). Preparing teachers for inclusive education: Using inclusive pedagogy to enhance teaching and learning for all. *Cambridge Journal of Education, 40*(4), 369–386.

Harrison, L., & Treviranus, J. (2003). Accessible e-learning—Demystifying IMS specifications. In A. Rossett (Ed.), *Proceedings of world conference on e-learning in corporate, government, healthcare, and higher education 2003* (pp. 2000–2003). Chesapeake: AACE.

IEEE Learning Technology Standards Committee (LTSC). (2005). Final standard for learning object metadata. http://ltsc.ieee.org/wg12/files/IEEE_1484_12_03_d8_submitted.pdf. Accessed 30 Oct 2013.

IMS Global Learning Consortium (GLC). (2004). IMS AccessForAll Meta-data overview. http://www.imsglobal.org/accessibility/accmdv1p0/imsaccmd_oviewv1p0.html. Accessed 30 Oct 2013.

IMS Global Learning Consortium (GLC). (2005). IMS application profile guidelines overview. http://www.imsglobal.org/ap/apv1p0/imsap_oviewv1p0.html. Accessed 30 Oct 2013.

ISO/IEC JTC1/SC36 24751-2. (2008a). Individualized adaptability and accessibility in e-learning, education and training—Part 2: "Access for all" personal needs and preferences for digital delivery. http://www.iso.org/iso/catalogue_detail.htm?csnumber=43603. Accessed 30 Oct 2013.

ISO/IEC JTC1/SC36 24751-3. (2008b). Information technology—Individualized adaptability and accessibility in e-learning, education and training—Part 3: "Access for all" digital resource description. http://www.iso.org/iso/catalogue_detail.htm?csnumber=43604. Accessed 30 Oct 2013.

Lee, L. W. (2010). Structural and pedagogical design of learning objects to support special education teachers. *Global Learn, 2010*(1), 3609–3614.

Nevile, L., Cooper, M., Health, A., Rothberg, M., & Treviranus, J. (2005). *Learner-centred accessibility for interoperable web-based educational systems.* In Proceedings of the 14th International World Wide Web conference. New York: ACM.

Pynoo, B., Tondeur, J., van Braak, J., Duyck, W., Sijnave, B., & Duyck, P. (2011). *Assessing teachers' acceptance of educational technologies: Beware for the congruency between user acceptance and actual use.* In Proceedings of the 19th International Conference on Computers in Education (ICCE-2011). Ghent University, Department of Educational Studies.

Rose, D. H., & Meyer, A. (2002). *Teaching every student in the digital age: Universal design for learning.* Alexandria: Association for Supervision and Curriculum Development.

Seale, J., & Cooper, M. (2010). E-learning and accessibility: An exploration of the potential role of generic pedagogical tools. *Computers & Education, 54*(4), 1107–1116.

Ternier, S., Verbert, K., Parra, G., Vandeputte, B., Klerkx, J., Duval, E., Ordonez, V., & Ochoa, X. (2009). The Ariadne infrastructure for managing and storing metadata. *IEEE Internet Computing, 13*(4), 18–25.

Tomlinson, C. A., & McTighe, J. (2006). *Integrating differentiated instruction and understanding by design: Connecting content and kids.* Alexandria: Association for Supervision and Curriculum Development.

W3C. (2008). Web content accessibility guidelines 2.0. http://www.w3.org/TR/WCAG20/. Accessed 30 Oct 2010.

Chapter 6
Development of Visualization of Learning Outcomes Using Curriculum Mapping

Takashi Ikuta and Yasushi Gotoh

1 Background

We live in an age where higher educational institutions all over the world offer teaching materials and online courses on networks from which people can learn freely, massive open online courses (MOOCs) being the prime example. These teaching materials and online courses exist individually so that people learn by selecting what they themselves need from what is on offer. In such an age, what is required is the ability to set our own learning targets, grasp how far we have progressed towards the attainment of these targets and to design the next learning activity. Under these circumstances, it is essential for individual learners to have an overall grasp of the extent of their progress towards their targets.

In higher learning up till now, the idea of individual learners having an overall grasp of their attainment level with reference to a target did not exist. This was because the teachers providing the curriculum were specialists in specific domains and did not pay much attention to students' overall growth and development. The students for their part studied only the specialized subjects set out for them and did not appreciate what they learned from the perspective of the global question: To the formation of which attributes and skills does each subject contribute?

In universities, these attributes and skills are known as 'graduate attributes'. How to guarantee graduate attributes is a pressing issue amid the progress in science and technology and the increasing globalization of economic activities. In Japan, we have been discussing graduate abilities and domain-specific quality assurance modelled on the UK's Quality Assurance in Higher Education (Quality Assurance Agency for Higher Education 2001) as a framework. Domain-specific quality assurance considers the basic knowledge and understanding, domain-specific skills and generic skills

T. Ikuta (✉) · Y. Gotoh
Niigata University, 8050 Ikarashi 2no-cho,
Nishi ward, Niigata City, Niigata, Japan
e-mail: ikuta@ed.niigata-u.ac.jp

Y. Gotoh
e-mail: gotoh@ge.niigata-u.ac.jp

D. G. Sampson et al. (eds.), *Digital Systems for Open Access to Formal and Informal Learning*,
DOI 10.1007/978-3-319-02264-2_6,

which are the fundamental elements that a student must acquire in a specific academic domain, and the teaching methods and assessments which help students to learn, and seeks to turn these into reference standards for the formation of educational processes in each domain. Here, the focus is on the global appreciation of the attributes and skills which go into the formation of a student.

On the basis of these considerations, Niigata University has started to develop the Niigata University Bachelor Assessment System (NBAS). As a framework for a global appreciation of the attributes and skills which form a student, the university has established four educational target domains: knowledge and understanding, domain-specific skills, generic skills and attitude.

Of course, it is difficult to gain a global appreciation of the attributes and skills forming a student merely by piling up results in individual subjects. In personal development planning (PDP) as recommended in the UK, students themselves are supposed to reflect and foster the skills required to plan their lifelong development, on the basis of grades transcripts provided by the university and personal development records (PDR) compiled by the student. However, it has also been reported (Benesse Educational Research and Development Institute 2008) that PDP demands an enormous amount of effort and expense and does not lead to a good grasp of learning outcomes. Domain-specific quality assurance mentioned above also does not go as far as to examine the mechanisms for verifying the relationship between attributes and skills such as knowledge and understanding, domain-specific skills and generic skills, i.e. the basic elements which a student must acquire, and the individual subjects studied by the student, and for appreciating and expressing these from a global point of view.

This is why Niigata University set about developing a system (NBAS) for expressing and visualizing in a radar chart students' attainment level in terms of learning outcomes. The system uses a curriculum map which sets attainment targets low down in the educational target domain and clarifies the relationship between attainment targets and individual subjects. In this way, it is not enough for teachers in educational programmes to be specialists in a specific domain. Rather, they must have an awareness, from the perspective of graduate attributes, of where the subject they teach is positioned in the curriculum and whether it contributes to graduate attributes. Kawashima (2008) points out the need for teaching bodies involved in educational programmes to discuss learning outcomes with the aim of developing human resources. Efforts to visualize learning outcomes as a whole are in the process of evolving; from seeing themselves as specialists in a specific domain teaching an individual subject, teachers now have started thinking of themselves as component members of an educational programme focussed on understanding learning outcomes (Ikuta and Gotoh 2011).

Visualized learning outcomes are the global expression of the human resource development which educational programmes aim to achieve. They must be expressed individually in the context of each individual student. Since visualized learning outcomes are a global expression, the premise is that the radar chart displayed by the system reflects the actual attributes and skills of the student (Namikawa et al. 2012).

The present study examines whether visualized learning outcomes provide an overall picture of graduate attributes and skills by looking at students and teaching bodies involved in educational programmes.

2 Outline of NBAS

The goal of NBAS is to have students establish their own learning targets, proceed independently with their learning, verify their visualized attainment level, design their next learning activity and develop new learning activities.

Using this system, students can reflect on what they have learned and carry out process assessments (Ikuta and Gotoh 2011). Reflection on learning is the act of comprehending one's own learning in a metacognitive way while looking back on the learning process. Only by asking himself/herself, 'What does meaningful learning mean for me? What are my strong points? What are my weak points?' can the student become an autonomous learner. In order to support such reflection on learning, it is important to have an assessment by a guidance teacher to whom one can talk.

Rather than absorbing what the university prescribes for them, we want students to be aware of their own learning goals, make their own plans and cultivate an attitude conducive to learning. This is why process assessment was established. In process assessment, the student reflects on his/her learning by verifying learning outcomes and using information he/she has recorded about the learning process, in order to give meaning to what he/she has learned so far and connect what he/she has already learned with his/her learning design for the next stage in the process.

For process assessment, NBAS registers and arranges information recorded in the learning process from perspectives such as learning field, attainment target and information type. For example, a student might extract learning record information about a target that seems particularly relevant to him/her among the attainment targets, and in this way give meaning to and reflect on his/her learning. In process assessment, the teacher in charge of the programme on the other hand looks at information about the courses taken by a student, the student's life and the qualifications he/she is aiming for, and provides assessment, advice and mentoring. Process assessment is carried out each semester, and assists students in accumulating autonomous learning.

Assessment at graduation is where the student himself/herself displays the attributes and skills appropriate to be awarded of by a bachelor's degree. In assessment at graduation, the final verification is done by learning the outcomes from attainment targets in four domains, and this is expressed on the basis of evidence about the overall graduate level reached by the student. The attainment targets in these four domains describe the fact that in each domain the student has attained the standard appropriate to a graduate of Niigata University. They are also based on evidence about the individual characteristics of the student's own graduate ability.

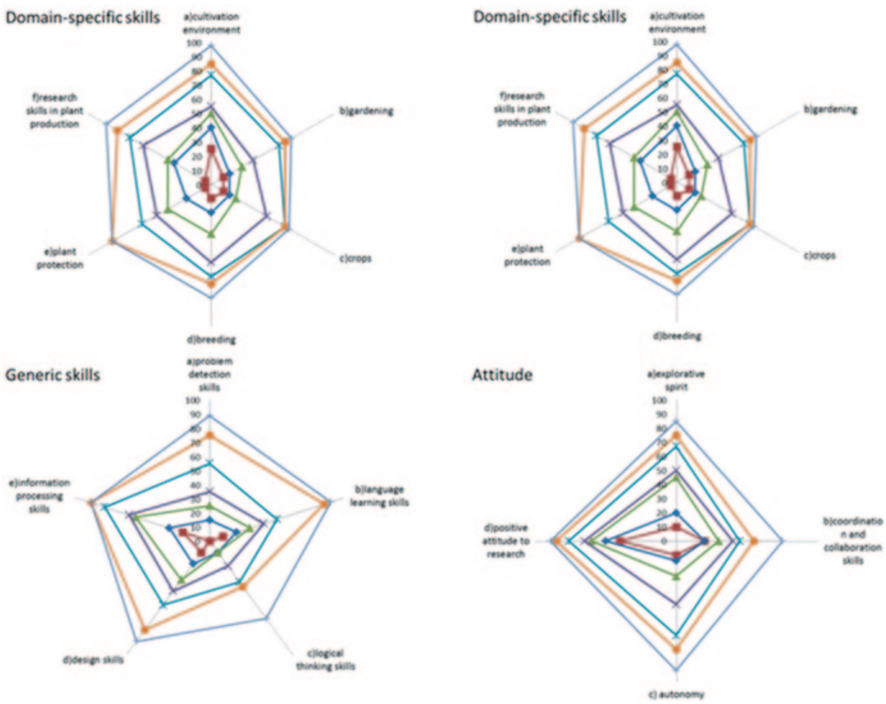


Fig. 6.1 Visualized learning outcomes

The objective, in using NBAS, is to have students develop an attitude in which they are proactive in setting their own targets, understanding their attainment level and designing their next learning activity. The attitude formed here also converts to informal learning.

3 Visualization of Learning Outcomes

The visualization method for learning outcomes is the same as the one shown in Ikuta and Gotoh (2011). First, the educational target domain is split into domain-specific academic knowledge, domain-specific skills, generic skills and attitude, and attainment targets are set low down on these educational targets. Next, a contribution ratio is assigned to the attainment targets in each subject forming the education programme. For example, in subject A, the attainment target in knowledge and understanding is 50 %, domain-specific skills 30 %, generic skills 10 % and attitude 10 %. Several attainment targets are set in each educational target domain. Where there are contributions to several attainment targets in knowledge and understanding, for example, a further 50% is allocated to each attainment target. The table compiled in this way is called a curriculum map.

The learning outcome is the total value of the score arrived at by multiplying the student's grade assessment by this contribution ratio and the number of credits. To give an example, if a student scores 80 points in subject A, the score of 80 is arrived at in the case of knowledge and understanding by multiplying 80 (points) $\times 0.5$ (50%) $\times 2$ (number of credits). The learning outcome is the aggregate score for all attainment targets (Fig. 6.1).

4 Examination of How Far it is Possible for Teachers on Major Programmes to Understand Learning Outcomes

First, in order to determine whether visualized learning outcomes really do express students' attributes and skills as a whole, teachers were interviewed to ask whether their impressions of a particular student coincided with that student's visualized learning outcomes.

4.1 Participants and Survey Period

Teachers interviewed were those attached to the life sciences programme, the forest environment programme and the agricultural engineering programme, and interviewers were teachers from the Institute of Education and Student Affairs. Interviews were conducted between October 2010 and June 2012.

4.2 Procedure

Teachers were presented with three types of material: radar charts of four education target domains for each individual student, using students' results data up till March 2012 (data at the end of the 3rd year in life sciences programmes, data at the end of the 4th year in forest environment and agricultural engineering programmes); material showing students' relative position in each attainment target; and the curriculum map.

Using these materials, teachers who knew the student in question well were asked if they could obtain an intuitive understanding of visualized learning outcomes based on actual students' results.

Interview data were turned into textual data, and each segment was divided and categorized. MAXQDA10 was used as analysis software.

In terms of the features of the three education programmes, life sciences is a programme in which students voluntarily choose the subjects they will study from among the specific domains of living science, clothing science, dietary habits and family resource management. For this reason, there is a mixture of students who focus in particular on one specific domain and students who cover all domains uniformly.

The forest environment and agricultural engineering programmes are accredited as engineering education programmes by the Japan Accreditation Board for Engineering Education. The education process is organized according to the construction of attainment targets. Therefore, until graduation, virtually all students study similar subjects. Students are also provided with guidance about the structure of attainment targets and about how to deepen their understanding of the subjects they are about to study, will be positioned on these attainment targets. In this sense, these programmes are in marked contrast to programmes such as life sciences.

There are 42 major programmes at Niigata University. These range from programmes such as life sciences where students have a wide choice of subjects, to programmes such as forest environment where they study subjects within a determined range. For this reason, our three programmes are representative of the programmes on offer.

4.3 Results

How Far is it Possible to Understand Visualized Learning Outcomes?

Let us first look at the life sciences programme. The investigation began by opening all the radar chart displays for individual students. The original data for visualized learning outcomes were the subject grades data. Therefore, unless one knows what subjects students are studying and what sort of grades they are getting, one cannot judge whether or not it is possible to understand a radar chart display. It would be confusing to attempt to examine all students at the same time since they study such diverse subjects. Hence, it was decided to examine, first, students whose learning situation was very familiar to the teacher, or students who belonged to a particular teacher's seminar.

Extracting students belonging to a seminar also means dividing them into specific fields such as living science, clothing science, dietary habits and family resource management. Students belonging to the same seminar study virtually identical subjects, and it was clear that in general the radar charts showed a similar pattern. In other words, students in the same specific field, naturally, have a high score in attainment targets closely related to their specific field. In addition, it was clear that in closely related attainment targets and generic skills outside a student's own specific field, the student's individuality came into play. Teachers were able to add an explanation about the circumstances surrounding individual attainment levels while they looked at individual students' radar charts. This confirmed that the teachers' actual impressions of students largely coincide with visualized learning outcomes. Someone also had the idea that since radar chart patterns are virtually identical for students in the same domain, this might prove useful for peer reviews carried out by students themselves, and for setting the next target.

Next, it was also clear that the learning process could be verified from radar charts. Since radar charts is a system for accumulating attainment level scores like age rings on trees, it is clear that we should be able to understand, to a certain extent, which subject in a specific domain a student was studying at a particular time and in what circumstances, by looking at the shape of the student's individual chart. For example, other teachers asked the guidance teacher about a student who improved spectacularly in a particular semester. "Why did this student get such good grades this semester?" they wondered, to which the guidance teacher replied that the student probably made an effort to obtain the required credits with good grades in response to advice that, in view of the courses he/she had completed, he/she did not have enough credits. Hence, not only learning outcomes but also information about the learning process can be read from radar charts.

In forest environment, on the other hand, the characteristics of the curriculum mean that the subjects studied by the students are virtually identical, and in many cases, the radar charts show the same overall shape. Put in terms of the previous example of life sciences, it is as if all students belonged to a seminar in the same specific field. In general, students with good grades have large radar charts, while those with poor grades have the opposite. Although the shapes as a whole are similar, students with good grades have a high peak showing a particularly high attainment level, while students with a low grade point average (GPA) have a characteristic radar chart where specific attainment targets remain low. Clearly, therefore, it was possible to obtain a visual understanding of which attainment targets have not been achieved. This information will likely to be useful when teachers are mentoring students.

On the whole, our investigation confirmed that visualized learning outcomes clearly express students' characteristics and are comprehensible.

Issues Relating to the Use of Visualized Learning Outcomes

We have seen that teachers' impressions about the student in question do coincide with visualized learning outcomes. At the same time, some teachers also indicated certain issues that came up when visualized outcomes were presented.

Since individual students' graphs emphasize the development of attainment targets which vary between students, these graphs show individual patterns. To enable students to carry out self-assessment of their own learning outcomes, some kind of indication corresponding to these patterns is required. Someone suggested that it might become simpler for students to assess themselves if they could compare the four life sciences role models of living science, clothing science, dietary habits and family resource management. At that point, someone else proposed methods such as using actual data from high-performing students or compiling virtual student data based on average values and modes in a particular subject.

Again, when considering materials that enable teachers to understand the relative position of a student in each attainment target, attention was drawn to the fact that some attainment targets seemed out of place. In some cases, students who seemed intuitively to deserve a higher position in terms of a particular attainment target did not come particularly high, while other students who did not seem particularly able were placed high up. A look at the weighted curriculum map showed that this was because only a few subjects were weighted in that attainment target. The low position of a student whom one might intuitively expect to be placed higher up was because for some reason the student had not studied that subject. It would appear that attainment targets are too fragmented, or that there are not enough weighted subjects. Where this type of discrepancy occurs, there is a need to consolidate attainment targets or increase the number of weighted subjects.

The correspondence between weighting towards attainment targets and actual assessments was also discussed. The assessment of a subject targeting knowledge and understanding is different from the assessment of one targeting generic skills. We also discussed whether an appropriate assessment should be made after weighting attainment targets.

Such discussions are concerned with what sort of attributes and skills the human resources in the care of these teachers should possess, where these attributes and skills should be fostered and how they should be assessed. It is clear that rather than reaching a final conclusion, the discussions must be ongoing.

5 Possibility of Comprehension by Students

Next, we will examine, by looking at case studies, whether it is possible for students themselves to understand visualized learning outcomes.

Students were asked to carry out self-assessment in each attainment target and subjectively assess the compatibility between visualized learning outcomes and their own assessment.

5.1 Participants and Survey Period

Twelve 4th-year students (eight men and four women) in the forest environment programme participated in the study. As explained earlier, in the forest environment programme, attainment targets are structured and the relationship between subjects and attainment targets is also common knowledge. Therefore, it would seem that students have a good enough understanding of attainment targets for self-assessment to be possible. The survey was carried out from December 2011 to January 2012.

5.2 Procedure

Following an explanation by teachers about attainment targets, the survey was carried out using a questionnaire.

First, we asked whether the contents of each attainment target (a total of 20 targets) in the Agricultural Department's forest environment programme could be understood (imaged). Five conditions, from 'I can image very well' to 'I can't image at all', were used. Students were also asked to self-assess each attainment target. Five targets from 'I have attained the target very well' to 'I haven't attained the target at all' were used.

Next, we asked the students to assess subjectively the compatibility between the visualized learning outcomes and their own self-assessments. We asked them to compare their self-assessments to a radar chart in each attainment target and to tell us how well they felt the radar chart expressed their learning outcomes. Five conditions from 'Expresses clearly' to 'Does not express at all' were used.

5.3 Results

Comprehension of Attainment Targets

Results showing to what extent the contents of each attainment target can be imaged are shown in Table 6.1. Overall, the results are high at 4.40 (standard deviation, SD = 0.69) showing that students can also image the target. Some very low scores were also observed, e.g. 'ethical viewpoint' in knowledge and understanding and 'employability' in generic skills had a relatively low average score of less than four, while 'language-learning skills' and 'spirit of challenge' in attitude had a minimum score of 2.

The four attainment targets in domain-specific skills, i.e. targets directly related to the specific field, and d)–f) in knowledge and understanding had an average score of four or above and the minimum score was never less than three. Therefore, it seems that targets related to specific fields are also to a certain extent comprehensible to students. Since participants in the survey were 4th-year students, we should probably look at how far comprehension is possible among 1st- and 2nd-year students too.

Self-Assessment of Attainment Targets

Next, let us look at the self-assessment of attainment targets. Average scores varied widely from 2.83 (SD = 0.94) for 'b) employability' in generic skills to 4.67 (SD = 0.65) for 'b) teamwork' in attitude. Someone also suggested that individual attainment targets should be separated for self-assessment. Moreover, while average scores were in general three or above, 'b) employability' alone, in generic

Table 6.1 How far do students comprehend attainment targets?

			Average score	Standard deviation	Minimum score	Maximum score
Knowledge and understanding	a	Wide perspective and deep culture	4.58	0.51	4	5
	b	Natural sciences and information literacy	4.33	0.65	3	5
	c	Ethical viewpoint	3.92	1.08	2	5
	d	Ecosystem services perspective	4.83	0.39	4	5
	e	Watershed management perspective	4.33	0.65	3	5
	f	Issue exploration technique	4.50	0.67	3	5
Domain-specific skills	a	Surveying	4.50	0.52	4	5
	b	Adaptive forest management	4.17	0.72	3	5
	c	Sustainable forest management	4.75	0.45	4	5
	d	Exploration issues in forestry	4.50	0.52	4	5
Generic skills	a	Language-learning skills	4.08	1.24	2	5
	b	Employability	3.58	1.24	2	5
	c	Multifaceted thinking ability	4.25	0.62	3	5
	d	Presentation skills	4.75	0.45	4	5
	e	Design skills	4.08	0.67	3	5
	f	Information-processing skills	4.50	0.67	3	5
Attitude	a	Spirit of challenge	4.25	0.87	2	5
	b	Teamwork	4.83	0.39	4	5
	c	Deliberation skills	4.42	0.90	3	5
	d	Fieldwork	4.83	0.58	3	5

Table 6.2 Self-assessment of each attainment target

			Average score	Standard deviation	Minimum score	Maximum score
Knowledge and understanding	a	Wide perspective and deep culture	3.50	0.90	2	5
	b	Natural sciences and information literacy	3.50	0.09	2	5
	c	Ethical viewpoint	3.58	0.09	2	5
	d	Ecosystem services perspective	4.25	0.62	3	5
	e	Watershed management perspective	3.42	1.24	2	5
	f	Issue exploration technique	3.58	1.00	2	5
Domain-specific skills	a	Surveying	3.75	1.06	2	5
	b	Adaptive forest management	4.00	0.95	3	5
	c	Sustainable forest management	4.17	0.83	3	5
	d	Exploration issues in forestry	3.50	1.17	2	5
Generic skills	a	Language-learning skills	3.00	1.41	1	5
	b	Employability	2.83	0.94	2	4
	c	Multifaceted thinking ability	3.83	0.72	3	5
	d	Presentation skills	3.75	1.06	2	5
	e	Design skills	3.17	0.94	2	5
	f	Information-processing skills	3.50	1.00	1	5
Attitude	a	Spirit of challenge	4.00	1.21	1	5
	b	Teamwork	4.67	0.65	3	5
	c	Deliberation skills	3.75	0.97	2	5
	d	Fieldwork	4.17	1.11	2	5

Table 6.3 Students' comprehension of radar charts

			Average score	Standard deviation	Minimum score	Maximum score
Knowledge and understanding	a	Wide perspective and deep culture	3.73	1.27	2	5
	b	Natural sciences and information literacy	3.83	0.94	2	5
	c	Ethical viewpoint	3.92	1.00	2	5
	d	Ecosystem services perspective	3.67	0.89	2	5
	e	Watershed management perspective	3.33	1.23	2	5
	f	Issue exploration technique	3.58	0.79	2	5
Domain-specific skills	a	Surveying	4.17	0.58	3	5
	b	Adaptive forest management	3.58	0.90	2	5
	c	Sustainable forest management	3.75	0.87	2	5
	d	Exploration issues in forestry	3.83	0.83	2	5
Generic skills	a	Language-learning skills	2.50	0.90	1	4
	b	Employability	3.33	0.98	2	5
	c	Multifaceted thinking ability	3.92	0.79	3	5
	d	Presentation skills	4.17	0.72	3	5
	e	Design skills	3.58	1.08	2	5
	f	Information-processing skills	3.92	0.79	2	5
Attitude	a	Spirit of challenge	3.67	1.07	2	5
	b	Teamwork	4.00	1.13	2	5
	c	Deliberation skills	3.92	0.67	3	5
	d	Fieldwork	3.33	1.23	2	5

skills, was less than three. Again, while in other domains such as knowledge and understanding, at least one attainment target scored four or more, attainment targets included in generic skills were all less than four. Hence, it would seem that self-assessments of general skills vary widely in comparison to those in subjects related to a student's specific domain (Table 6.2).

Assessment of Visualized Learning Outcomes

In terms of how students feel about how well radar charts express their own learning outcomes, it would seem from the average score for radar charts in general of 3.45 (SD = 0.82) that an assessment of 'to a certain extent' (Table 6.3) was obtained. Nevertheless, 'a) language-learning skills in generic skills' showed an average score of 2.50 (SD = 0.90), the only target to fall below three, i.e. 'Can't say one way or the other'. Again, since it was only in 'a) language-learning skills' that the answer 'Expresses clearly' was never obtained, some discussion is needed. Moreover, in the current curriculum, it was only in the subjects of 'English' and 'First foreign language' that 'a) language-learning skills' was weighted and on the whole, the number of credits was also small. Again, in general, these subjects are often studied in the 1st and 2nd years, so in the case of the 4th-year students carrying out the assessment, the fact that some time had elapsed since they studied them was probably a factor.

6 Discussion

According to discussions based on teachers' subjective judgment, visualized learning outcomes are generally good at expressing students' attributes and skills, and are useful for understanding the attainment level in attainment targets which cannot be understood simply by GPA or grades data. In future, these conclusions will have to be validated by weighted amendments and lesson contents and assessments to suit these weightings.

Again, it was clear from students' discussions that students could carry out self-assessment based on an understanding of attainment targets set by teachers, and could judge that visualized outcomes were appropriate in many of the attainment targets. On the other hand, since the level of understanding was not very high in some attainment targets, continued investigation is required.

As mentioned at the start of this study, teachers must change their perceptions. From seeing themselves as specialists in a specific domain offering instruction in an individual subject, they must come to see themselves as component members of an educational programme. For this, it is essential that they ask themselves what sort of human resources possessing which type of graduate attributes they hope to foster. The authors have suggested (Ikuta and Gotoh 2011) that, 'If individual teachers revise the syllabus, extract attainment targets and consider assessment methods and grade allocations in the educational program as a whole, they will be able to discuss educational programs in general for fostering human resources in a global sense, rather than only from the perspective of domain-specific knowledge. Such discussions will be useful and have wide-ranging potential application in assuring quality in higher education'. We want individual teachers to ask, 'How will students get on in my class in practice when it comes to acquiring the attributes and skills which an educational programme attempts to foster? What lessons should I design in order to foster these skills and how should I assess them?' In conducting such discussions, visualized learning outcomes will be a very useful tools.

This research method is useful not only in formal learning. Network learning materials and online courses are other situations in which it can be used. These are individual parts, and in terms of formal learning, correspond to the credits required for graduation. It is the learner himself/herself who improves his/her mental capabilities and goes further in his/her career by putting these together. If the learners themselves can grasp, as a whole, the attributes and skills they themselves have acquired, then this will be useful in designing the next learning activity (Harteloh 2009). In lifelong learning, whether formal or informal, it is essential to acquire an attitude in which the learner sets his/her own learning targets, grasps his/her level of attainment and designs what to learn next. Efforts by NBAS to visualize learning outcomes could be a model for these lifelong learning practices.

References

Benesse Educational Research and Development Institute. (2008). *Progress in higher education reform in the UK on the basis of the dearing report and survey report on career education promotion cases using education coordinators in Europe and the US* (Report on Trends in Higher Education Reform in the UK). http://benesse.jp/berd/center/open/report/oubei_19/index.html. Accessed 15 Sept 2013.

Harteloh, P. (2009) Innovating quality management of university education. *Gendai Syakai to Daigaku Hyouka, 5,* 1–17. (in Japanese)

Ikuta, T., & Gotoh, Y. (2011). *Visualization of learning outcomes using curriculum mapping, Takashi Ikuta and Yasushi Gotoh*. Proceedings of the IADIS International Conference on Cognition and Exploratory Learning in the Digital Age, 2011. Rio de Janeiro, Brazil pp. 323–325.

Namikawa, T., Sawabe, J., Gotoh, Y., Satoh, Y., Gotoh, J., & Shimizu, A. (2012). *Totatsu mokuhyou oyobi gakusyuuseika no kashika no datousei ni kansuru kentou (1)*. Proceedings of Japan Society of Educational Psychology, Nakagusuku, Japan.

Quality Assurance Agency for Higher Education. (2001). *Guidelines for HE progress files*. http://www.qaa.ac.uk/Publications/InformationAndGuidance/Documents/progfile2001.pdf. Accessed 15 Sept 2013.

Kawashima, T. (2008). International trends in outcome-based higher education reform and teir implications for Japanese higher education. *Nagoya Higher Education Research, 8,* 173–191.

Chapter 7
Assessing Student Learning Online

Overcoming Reliability Issues

Stephen D. Arnold

1 Introduction

Assessment is the process of collecting, synthesizing, and interpreting information in order to make a decision (Airasian and Russell 2007). In the college class, this decision inevitably not only includes students' grades but it also ties to teachers' success in covering the content effectively, preparedness of students, and the accreditation worthiness of programs in academically preparing students for the larger picture. Value in any instructional system comes from assessment; what is assessed in a course or a program is generally associated with value; what is valued becomes the focus of activity (Swan et al. 2007). Effective assessment typically includes ongoing "formative assessment" checkpoints and end-of-term "summative assessment." Instructors signal what knowledge skills and behaviors they believe are most important by assessing them, while students quickly respond by focusing their learning accordingly (Swan et al. 2007). The end-of-course assessment method, and more specifically the requirements that underlie this assessment mode, make a difference to the outcome (Struyven et al. 2006). Considering that stability reliability equates to consistency of test results over time (Popham 2011), it is safe to assume that the processes involved in assessment from day 1 to the end of the term can have a vast impact on reliability. Systematic processes of reliable assessment do not end after a test is developed, especially in the online sector.

In online, asynchronous courses, whereby the students and instructor do not meet, obtaining reliable assessment measures becomes more difficult than in a traditional face-to-face (F2F) class. It is important to collect several pieces of information about the performance being assessed to increase reliability (Airasian and Russell 2007). Although it is possible as an instructor to elicit online quizzes, papers, and projects from students, there is still the dilemma of determining who is (and how many are) involved in the submission of the common assessment items.

S. D. Arnold (✉)
University of Arizona South, UA Science & Technology Park, 9040 South Rita Rd., Tucson, AZ 85747, USA
e-mail: sdarnold@email.arizona.edu

D. G. Sampson et al. (eds.), *Digital Systems for Open Access to Formal and Informal Learning,*
DOI 10.1007/978-3-319-02264-2_7,

Today's movement toward exponentially higher online enrollments and the ensuing assessment issues is best illustrated by the Massive Open Online Course (MOOC) euphoria. Aside from the extremely low completion rates, MOOCs are faced with the challenge of how to effectively assess thousands of students enrolled in these courses each semester. Reliability of assessment in the MOOC scenario is not so critical with regard to grading since the vast majority of students are taking the courses in the noncredit, open learning capacity. With the talk of moving toward degree fulfilling, credit-earning MOOCs, reliability is a major hurdle that will have to be addressed, however. The viewpoint of one instructor from a highly ranked school may capture the magnitude of reliability issues faced in the move toward larger online enrollments when he said that he likes the idea of drilling students with online quizzes, but his own MIT students would have to work on theirs in a classroom with a proctor (Kolowich 2013a).

There are issues with the course management system (CMS) interfaces that influence testing processes in a manner that impacts results. Clearly, different approaches will have to be implemented when teaching a class of 20 local students versus a class enrollment of 33,000 globally, which is the MOOC mean according to Kolowich (2013a). As a means to strengthen assessment reliability and foster students' creative engagement, the use of alternative digital pontifications must be examined and discussed as a viable means to foster more reliable assessment outcomes for students and instructors in lower-enrollment, local online courses. In the higher-enrollment courses, in-person or virtually proctored assessments must be explored.

2 Input and Output

It is possible to look at the process of developing one's content knowledge as "input" and demonstrating what one knows as "output." More commonly, this is referred to as learning and assessment. Hunter (2004) equated the terms with input of information into the students' cognitive learning processes and output of information in a mastery of the learning-objective sense so that proper assessment may occur. Output is also associated with the active process of learning, whereby the process of output draws heavily upon the content knowledge students experienced through the input process reinforcing the learning (Arnold and Moshchenko 2009). When students are given the opportunity to produce a tangible product or demonstrate something to an audience, their willingness to put forth quality increases (McTighe 1996). As preservice teachers in technology for educators courses, students' input comes through the convergence of four primary areas: (1) K–12 subject matter (math, science, etc.), (2) pedagogical knowledge (how to teach effectively with technology), (3) technological knowledge (usually through extensive technology tutorials), and (4) educational technology foundations (content knowledge that pertains to why we use technology). Students synthesize this information and produce digital and tangible output which further reinforces the input process while demonstrating learning growth (see Fig. 7.1).

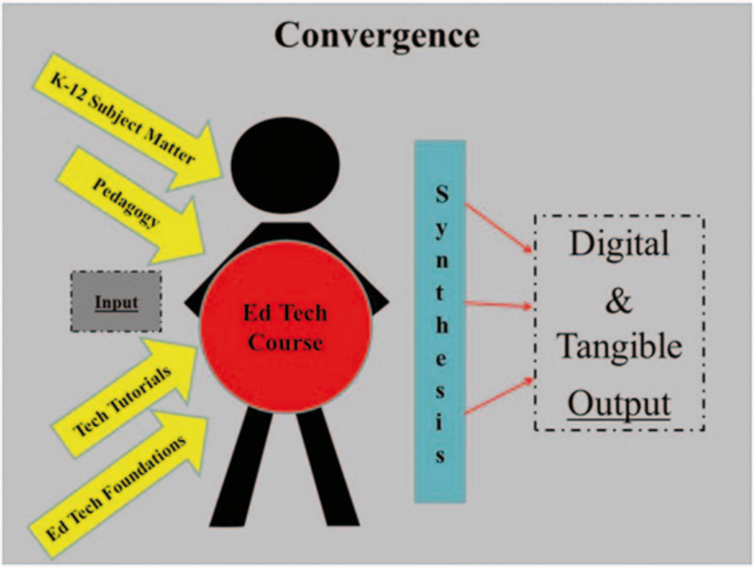


Fig. 7.1 Convergence of multiple knowledge tracks maximizes the input/output process

3 Assessment

In any course, measuring the growth students have made toward the objectives is critical to determine the effectiveness of instruction. As instructors, we have to be certain that our efforts are resulting in optimum outcomes for students. In higher education, written exams are often the assessment means of choice due to large numbers of students and limited instructor time. Depending upon the academic major, there is oftentimes professional dissonance between the weight of project, presentation, discussion, prose, and exam-evidenced proficiency being required of students. Final course grades and exams are the most common measures of learning outcomes for seniors across majors, however (NSSE 2010). Scheduled test events tend to increase students' study-time efficiency (McKenzie 1979).

In addition to measuring the level of proficiency growth, the assessment process further stimulates students' repetition and engagement with the course content. Highly familiar, meaningful stimuli subjected to increased processing time are directly correlated to increased retention of the stimuli (Craik and Lockhart 1972). More frequent assessment episodes, such as weekly quizzes, provide an increase in focused processing time. Roediger et al. (2011) identified ten benefits of testing:

1. Retrieval induced by testing facilitates later retention
2. Identifies gaps in knowledge
3. Causes students to learn more from the next learning episode
4. Produces better organization of knowledge
5. Improves transfer of knowledge to new contexts

6. Facilitates retrieval of information that was not tested
7. Improves metacognitive monitoring
8. Prevents interference from prior material when learning new material
9. Provides feedback to instructors
10. Encourages students to study

Assessment is an important opportunity for student learning as well as a means for instructors to judge student performance and assign grades (Thorpe 1998).

3.1 Types of Assessment

There are many categorizations of assessment. First, it is possible to make a distinction between assessment and test, with the first being the process of determining the learning gains, and the second being the instrument or measurement tool for gathering the data. Some use the terms evaluation and assessment in a similar manner. It is important to consider the time-based snapshots of learning, which are addressed by ongoing incremental *formative* measurements and the culminating end-of-term *summative* measurement. Tests by themselves are not formative or summative (Popham 2011); it depends upon whether the test results are used for in-process analysis or outcome quality.

When looking at the instrument for gathering measures of learning itself, there are two achievement test-output categories to be considered: conceptual (commonly constructed and selected response) and performance (applied, task-oriented). Constructed response tests (short answer, essay) blur the boundaries between conceptual and performance. They are conceptual, and sometimes performance. Like stories, reports, or show-your-work problems, essays and extended-response test items are important forms of performance assessments (Airasian and Russell 2007). Educators' perspective on what constitutes performance varies, but the existence of three common characteristics prevails in identifying assessment as performance: (a) multiple evaluative criteria, (b) prespecified quality standards, and (c) judgmental appraisal (Popham 2011).

Careful design of learning measures in the context of Bloom's taxonomy of instructional objectives can further propagate performance when students are expected to recall and apply information in an actual task. In some cases, schools require student exhibitions, culminating projects, experiments, solving of realistic math problems, and various other demonstrations of competence (Slavin 2012).

3.2 Informal and Formal Assessment

When considering the possible data-gathering methods in the formative assessment realm, it is important to consider the purpose and weight of the check on learning. If the stakes are low, and the intent is to spur students to self-analyze their understanding of the material, informal snapshots of progress will suffice. In this

Table 7.1 Characteristics of informal and formal assessments. (Williams and Suen 1998)

Characteristic	Informal	Formal
Degree of freedom	Spontaneous assessment activities	Planned assessment activities
Flexibility	Flexible procedures/protocols	Prescribed procedures/protocols
Information	Depth of information	Precision of information
Objectivity	Subjective impressions	Objective measurement scores
Utility	Maximal informativeness	Maximal comparability
Bias	Subjective bias	Potential narrowed scope
Setting	Natural settings	Controlled settings
Inference	Broad inferences	Strong inferences

regard, a threaded or in-class discussion, a short written assignment, laboratories, or a weekly quiz can help illuminate students' connection with the course content. Through their work on these assignments, students discover weaknesses with the subject matter and have the chance to revisit content (Thorpe 1998).

The formative assessment event also delves into the formal assessment realm quite often. This typically materializes in the form of incremental, high-stakes exams (including midterms), presentations, and robust papers. The score, instructor feedback, and follow-up discussion of the formal check on learning act as a diagnostic tool for both the students and the instructor. For students, the corrective action may include increased study sessions and attendance of recitations. For the instructor, it may be analysis of the supplemental course materials, addition of recitations, and test-item analysis.

When combined in a concerted manner, informal and formal assessments provide meaningful information from which valid inferences can be made (Williams and Suen 1998). There is no unique formula for combining the two, but they must support each other in obtaining a reliable assessment picture of students and the instruction they complete. If the grading weight of informal checks on learning, such as quizzes, is kept relatively low, the in-process tools can act as preemptive indicators without overtly compromising students' final score. At the same time, students will maintain a shred of performance motivation while instructors have an indicator to redirect efforts toward points of student misunderstanding. Williams and Suen (1998) identified eight characteristic variances between informal and formal assessments as noted in Table 7.1.

3.3 Exploring Online Assessment Options

In online courses, the assessment options are impacted by the student population demographics. Although students take online courses frequently at the campus of which they are a resident due to schedule restraints, remote students pose the greatest assessment challenge. Nothing illustrates this point greater than the recent surge in MOOCs by highly ranked, large universities. Enrollments have hit 180,000 in a single course (Kolowich 2013b). Meeting the assessment needs of a population this large has only one option at this stage of the development, massive open online testing (MOOT).

On the other end of the enrollment spectrum, instructors have many more viable options for assessing students in capped regional online courses (CROCs). If a course is capped at 20–50, as is the case in many upper division courses, the assessment medium possibilities increase. Adding one or more teaching assistants provides added support for grading, but may pose reliability issues with regard to multireviewer subjectivity. The reduction of student numbers and the increase in instructor support allow opportunities for implementing more constructed written-response and performance-oriented activities as triangulated measures of learning performance. Additional details on MOOC and CROC assessment options will be discussed later.

3.4 Assessment Reliability

Reliability is commonly broken down into three variants (Popham 2011): (a) stability (test–retest), which refers to obtaining consistent results among different test occasions; (b) alternate form, which is the consistency of results among two or more different test forms (multiple-choice vs. essay for instance); and (c) internal consistency, referring to the way the test items in a single test function cohesively. Since this chapter is focusing on different test occasions (stability reliability) and various forms of assessment (alternate form reliability), internal consistency reliability will not be developed beyond supportive reference in the scope of this chapter. It is assumed that as a college instructor you have already covered the tenets of recommended test-design practices. The focus then will center on stability and alternate form reliability. For further tips on test design, refer to the works of Popham (2011), Airasian and Russell (2007), Tuckman (1999), Gronlund and Waugh (2009), and McMillan (2011).

When circumstances allow having a test proctored for online students, it will increase its reliability. Reliability in this instance refers to consistency over time. If an instructor were able to administer a test to the same group of students repeatedly over time, ideally the results would be the same. When a test is administered, aspects related to the test construction itself, the student, graders, and various circumstances surrounding its administration could cause the results to be inconsistent (Slavin 2012). One major factor that can affect the reliability of a nonproctored online exam is its equivalence to a take-home or open-book test. In a face-to-face or proctored scenario, the test taker is being monitored, albeit there are still many reports of unconventional test-taking practices during the monitored environment as well. With the take-home scenario used in standard F2F classes, it is possible to have supplemental in-person exams to provide triangulated measures and context. Furthermore, the instructor has a constant in-person engagement with the students, which can provide an opportunity for oral dialogue on the subject matter. In the fully online situation, however, it is difficult to gauge who or how many are working on the same exam. Given such a test, reliability is compromised.

4 Boosting Online Assessment Reliability

In the online testing environment, there are many techniques that one can implement to help reduce the reliability reduction: set the course management system to give random questions, place strict time limits on how long a student can spend completing the exam, make the exam available only within a short period of time (4 h on Wednesday for instance), allow only one or a few simultaneous users to complete a test at a time, alleviate moving backward in an exam, and request elaborate applied examples (not previously mentioned in the instruction) where applicable. Although this will make dishonest test taking more difficult, it will not foil determined collaborators or complex cheating schemes.

4.1 Time and Resources

The main issue with any of the alternatives for increasing online assessment reliability is time and resources. In a class of 20 students (i.e., a 20:1 student to instructor ratio), it is possible to implement assessment activities that require a person to evaluate each individual submission. When the student to instructor ratio expands, limited time inevitably forces an automated grading system that is confined to selected response instruments (choose an answer). This is not to say that selected response assessment is only a stand-in due to limited resource design. It is really the call of the instructor whether or not a selected response exam will adequately represent students' proficiency with the course subject matter. With selected-response instruments, it is still possible to write questions in a manner that leads students through a scenario cognitively speaking, have them perform a hands-on task (depending upon the testing environment), and select the appropriate response. Math story problems are a great example of this process. The term performance-oriented describes this process in a manner that approaches the performance-based process. Despite much criticism of selected-response exams, it is possible to tap students' higher-order thought processes through questions based upon varied taxonomies of educational objectives. There are times when knowledge-level understanding is necessary, and times when application or evaluation is necessary (Slavin 2012).

4.2 In-Person and Virtual Proctoring

The most obvious way to increase the likelihood that a student is the individual taking all the tests and the same person receiving the end-of-course grade is via identification verification and close in-person monitoring. Within this system, there are still instances of cheating that result in misrepresented outcomes or a decrease in stability reliability. The question to ponder is whether the take-home test or those completed online will have higher rates of academic dishonesty. In one study (Watson and Sottile 2010), students reported equitable rates of cheating in F2F classes as compared to online classes, but 5.2 % more had someone else give them answers during an online class quiz or test than in the F2F environment. Another question to ask is whether students who cheat would actually provide honest answers on a questionnaire intended to determine the rate of cheating.

Many instructors rest easier having exams take place under direct supervision. If you are an instructor who assesses students exclusively on essays or projects originating outside instructor or teaching assistant (TA) observance, questions of who and how many were involved may linger. Many colleges offer proctoring services where students can complete exams. A number of community, discipline-oriented, and private organizations provide this service as well including libraries and national testing services. Educational Testing Service (ETS) and Pearson Vue are two examples of private companies that administer many national certification exams.

Major issues pertaining to proctoring exist with regard to geographically place-bound students and the cost involved in setting up proctors. If monetary resources are not an issue, alternative options that mesh with today's technology footprint exist for offering proctoring services to remote students. Proctor U, Kryterion Inc., Pass My Exam, and Proctor Cam are a handful of the online proctoring service providers. They typically have an authentication process to determine the identity of the test taker. This includes ID verification, personal information verification, and real-time monitoring of the student via webcams and screen sharing.

5 Assessing Capped Regional Online Courses

In CROCs that are in fact capped with manageable numbers allowing individualized attention, instructors have many options for gathering assessment data. Multisource feedback for students provides triangulated measures of learning while allowing engagement that meets a variety of teaching and learning preferences.

5.1 Common Measures

Quizzes and exams have long been established as viable means of determining student-learning outcomes in college courses. One major variance between tests and other engagement activities is the reliance upon memory. It is generally believed that the information one remembers is what has been learned. In the online CMS environment, there are many options that will help increase the reliability of the quizzes and exams looking exclusively at the online delivery mechanisms. The following list highlights some of these items:

1. Limit the time to complete
2. Set the exam to be available for a short amount of time
3. Randomize question–response order
4. Randomize questions that each student receives
5. If multiple takes are allowed, set a minimum score for the first attempt before a second will be allowed
6. Conduct item analysis for each question (many CMSs calculate the data automatically)
7. Encourage student feedback after each question and exam
8. Preview each question closely if using test banks provided by textbook companies
9. Set CMS to allow only certain IP addresses
10. Categorize questions by response type
11. Provide clear directions for each section
12. Establish a specific protocol for glitches and resulting retakes

5.2 Virtual Interaction

Meeting with students online in videoconferencing is one way instructors assess students' content growth informally through interactive dialogue. Unfortunately, this poses a significant challenge due to the one-on-one time requirement, availability of videoconferencing technologies (hardware and software), and scheduling. Oftentimes, students indicate dissatisfaction when instructors of online courses offer them synchronously at scheduled times due to their time/place-bound circumstances. If a student is beyond a reasonable commuting distance or has set hours of employment, it is difficult to attend any scheduled class whether F2F or online. In the asynchronous delivery scenario, the time can be more forgiving, but the options for assessment are more limited.

5.3 Virtual Presentations

Group projects have the means to provide increased student understanding of content- and instructor-related advantages including multiple perspectives and pooled efforts (Young and Henquinet 2000). From an instructor's standpoint, presentations provide an alternative means for students to demonstrate their competency vested in a culminating course project (Arnold 2010). As a means to capture the presentation component of an F2F class in the online course delivery medium, major projects can be assigned with the presentation element at its core. The process of presenting acts as reinforcement for learning that will oftentimes motivate presenters toward adequate preparation and information grounding (Arnold 2010). Students are able to demonstrate meaningful, multidimensional tasks via this authentic assessment

(Montgomery 2002). This can be achieved through lecture-capture systems (Panopto, for instance) or through other computer-based presentation programs (Adobe Presenter, for instance).

5.4 Performance Pontification

Digital video editing is well suited for providing authentic, meaningful, reflective experiences for teachers (Calandra et al. 2009). If it is more pointed in its output with specific criteria, then it becomes a viable assessment tool. When constructed by the students who are being assessed, and as participants in the video, the instructor will be able to analyze the video for key levels of pontification pertaining to the course and assessment objectives as the following pontification assignment summary illustrates.

Arnold (2012) studied the feasibility of digital video editing through technology for educators courses, which were broken down into five modules, each with 3 weeks devoted to a specified theme. Given that the course is primarily for preservice teachers, the focus was on pedagogy and using technology to support the standards-based subjects in the classroom. Theoretically and practically, teaching requires substantive merging of content, pedagogy, and technology knowledge (Roblyer and Doering 2012). Each of the modules had an overarching technology-based theme with multiple technologies addressed, substantial readings, academic content standards tie-in, pedagogical foundation, and emphasis on integration. During each module, students use and create comprehensive projects with multiple cloud and computer-based technologies while exploring an instructional delivery/e-learning concept such as podcasting. These key assignments throughout the semester have students expound upon their growth in the course content through various digital outputs that incorporate text, static images, audio, video, or a combination.

As a culminating activity near the end of the term, students were given a choice to either create a comprehensive digital story or write a paper on a subject of interest that would be covered in an elementary classroom and that supports a content area. If they choose the video, they may create it as either an individual or a group project (self-selected groups).

It may be anything from science (rocket propulsion for instance) to a social message (wash your hands frequently to reduce germs) or any other subject you would expect students of your favorite grade level to learn (look in the content standards for a grade level and subject of choice to identify a specific performance objective). In the spirit of the "reality" TV mash-ups (i.e., "Survivor," for instance, where the program shows the tribes in action and then cuts away to an individual sharing his/her perspective on that action in an interview scenario), I would like you to intersperse yourself into the video as the teacher giving your perspective regarding the use of technology in the learning/teaching process and with your chosen subject, while teaching the viewer about a chosen topic (i.e., the earth's rotation/tilt and seasons). Students were encouraged to get kids involved if possible, and were given the latitude to complete it as a group project with other students.

In order to discern specific concepts critical to the learning outcomes, further detailed criteria were included. Some pertained to the technology skills, whereas others were targeting educational technology and integration with the elementary school subject-matter concepts. The following are abbreviated samples of measurable objectives included in the project:

1. Refer to and include specific educational technology supportive content from at least six journal article or textbook sources that were assigned during the term.
2. Devote about one-third of your video to talking about integrating technology into the classroom, and the remainder to teaching about a specific topic in a grade level and subject of choice. Be sure to combine them so it does not appear like two separate videos.
3. Include at least three motion video clips of yourself talking about integrating technology into teaching.
4. Include at least two separate audio clips of yourself talking about images, third-party motion video clips, technology integration, or explaining visual examples of the subject matter.
5. Connect with and identify multiple standards: information literacy, NETS*T, state academic content standards, and state educational technology standards for students.
6. Make the presence of each group member equitable and evident throughout the video.
7. Demonstrate competency with multiple technologies/processes: Movie Maker, Audacity, online file conversion, iTunes, YouTube, ID Tag Editor, synchronized and overlapping soundtrack, and narrations.
8. Effectively integrate still images, motion video, text slides, overlays, soundtracks, and narrations.
9. Include important elements of a presentation: introduction, body, and conclusion.

On a smaller scale, and in a similar manner, students were given a reading response assignment whereby they had to create an audio-narrated hypermedia presentation (PowerPoint) in which they identified key points made in the readings as text on the slides and discussed them in audio format. Having met with each student individually at the beginning of the semester in a videoconferencing site and requiring students to post audio introductions in their e-portfolios, the instructor was familiar with students' voices. Given such, it resulted in more personable assessment than written papers. When students devised audio-only pontifications, they were given reasoning and instruction on using a Wiki-embedded media player versus adding a more personable face to their audio compilations. This included embedding photos and personal information in their completed mp3 files using a program such as Mp3Tag, and embedding their audio files in Avatars (with the Voki program, for instance), which were in turn embedded in their Wiki e-portfolios.

A couple of drawbacks, especially pertaining to using multimedia in the online environment, include devising a systematically reliable audio/video evaluation means and the technological requirements for developing a video that represents one's content development. Validity is also important to this type of assessment.

Table 7.2 Performance pontification assessment criteria: TPACK

Pontification media assessment criteria		
Quality sources (peer-reviewed)	Duration	Technological detail
Encapsulates Ed Tech foundations	Optimum blend	Shared appropriately
Incorporates previous media covered	Self-presence	Submission deadline met
Reusable third-party media use/support	Standards-aligned	Includes K–12 students
Content source triangulation	Creativity	Teaches a topic/main point
Components of a *good* presentation	Media quality	Demonstrates design principles

Does the video allow an instructor to measure the conceptual knowledge that needs to be measured? Identifying the expected outcomes was not really a problem, but some students opted to read from scripts which can leave the evaluator wondering if the presenter is engaged or simply reading information that is not internalized.

5.5 *Evaluating Audio and Video*

From the grading perspective, there is still a disparity in reliability from one instructor to another. Multiple teachers grading the same essay paper will assign grades ranging from A to F with some teachers making few to no comments or marks on the papers, but instead just producing a grade (Brimi 2011). As noted above, there is a convergence of technology-use skills, technology integration with subject-matter propensity, and any given number of subtopics pertaining to educational technology covered in the course that must be weighed when evaluating a video produced by students of a technology for educators course. Time is a critical element in the analysis, but quality is the most decisive in determining if students are pontificating about the concepts covered in the course. In the scope of this analysis, most students were able to expound upon their chosen topic (a science lesson on volcanoes, for instance), but most commonly, underdeveloped their connection of the lesson topic to their use of technology to demonstrate it, or other examples of technology that would further support the teaching of the lesson. The next confounding factor that tended to affect students results, whether audio or multimedia, was the technology medium being used for the output (Table 7.2).

5.6 *Technological Factors*

Early in the course, the technology skillsets were more limiting to the quality of course concept-infused outputs than later in the term. Given such, the course was structured with less complex technological components in the beginning. Week-by-week new technologies are introduced. During the first 3-week module, students are introduced to relatively low-end technologies. During subsequent modules, as students' efficacy climbs, they are directed toward more complex technological

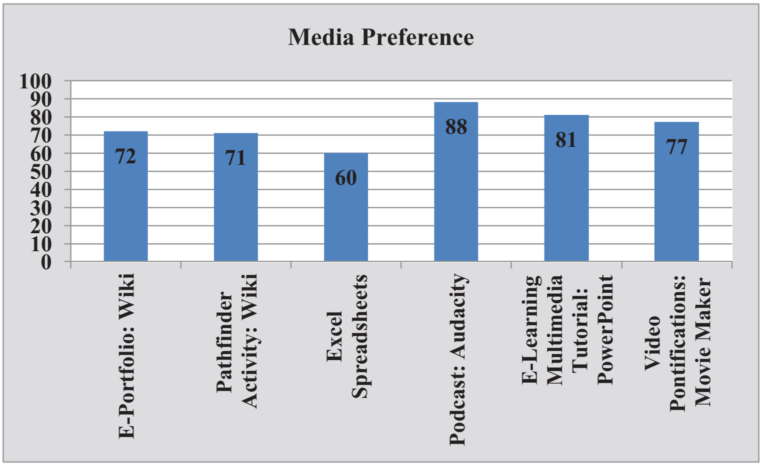


Fig. 7.2 Class rank-order preference of major projects

developments such as multitracked audio and video outputs using programs that balance user friendliness, effectiveness, and relatively free availability. These are characteristics that are likely to encourage preservice teachers to continue using technologies adequately when they transition to in-service status; a time that has many reeling from the steep learning and time commitment curve common during the first 2 years. Toward the end of the term, students in the technology for educators course are pushing some of the low-end technologies to their limit, which inevitably impacts their output and perception of technology.

5.7 Student Media Preferences

When students were asked if they preferred demonstrating content they have learned in the course through audio or video output (reading responses, interactive hypermedia, videos, etc.) over writing a paper on the same, 81 % strongly agreed and 19 % agreed. Given the number of technical glitches that were communicated during the term, it is curious that no students indicated preference for writing a pontification paper over creating the video. Perhaps, as Roblyer and Doering (2012) point out, technology can improve student motivation, attitude, and interest in learning.

In an end-of-course improvement evaluation, the instructor administers to students a rank-order question indicating that students prefer audio- and video-enriched technologies (see Fig. 7.2). The question only analyzed the larger project outputs without sub-analysis of the smaller technologies that most often fed into the larger projects. In the ranks for each project/media type, students identified Podcasting/Audacity (88) as their optimum output medium, with E-Learning/PPT (81) and Video Pontification/Movie Maker (77) close behind in that order.

Table 7.3 Student TPACK perception means

	Video		Podcast	
	Pre	Post	Pre	Post
Technology	8.67	7.81	8.86	7.62
Pedagogy	3.95	7.91	3.95	8.24
Content knowledge	4.86	8.48	5.14	8.10

In discussions with students, most seemed more enthusiastic about the outcome of their e-learning and video activities, although the higher rate of technology glitches, increased time commitment, and higher complexity level of the assignments associated with their development may have led to lower ranking than the podcast. Large file sizes, program freeze-ups, conversion to an iTunes U compatible mp4 file format, and student self-consciousness about presenting in the video were concerns voiced by students during the latter part of the term devoted to the multimedia projects.

5.8 Student Technology Perception

Students were given an additional questionnaire, the Technological Pedagogical Content Knowledge Alignment Perception Scale (TPACKAPS) at the beginning of the semester, and again at the end. Each student was asked to rate various components of the course (readings, discussions, papers, and media) on a scale from 1 to 10 for technology, pedagogy, and content knowledge emphasis (1 = none; 10 = primarily). Paired-samples *t*-tests were conducted to determine whether students' perception of the course components varied upon completion of the course. The results indicated that the pre and post means (Table 7.3) varied significantly at the $p < 0.01$ level in students' perceptions of videos and podcasts for technology, pedagogy, and content knowledge.

The positive correlation indicates that students perceive more technology-oriented focus in the beginning, but they perceive more pedagogy and content-knowledge focus after having substantial educational technology foundational development in conjunction with the media projects. When asked if they felt that media output represented their level of learning in the course with regard to technology, pedagogy, and content knowledge, 76 % strongly agreed, 14 % agreed, and 10 % neither agreed nor disagreed (see Fig. 7.3).

5.9 Impact of Digital Output

The results of this study indicate that students prefer multimedia over other types of technology, and view digital video and audio as TPACK-rich media capable of demonstrating their competencies. Students perceive more pedagogical and content-knowledge potential in media postexperiential, and with proper attention called

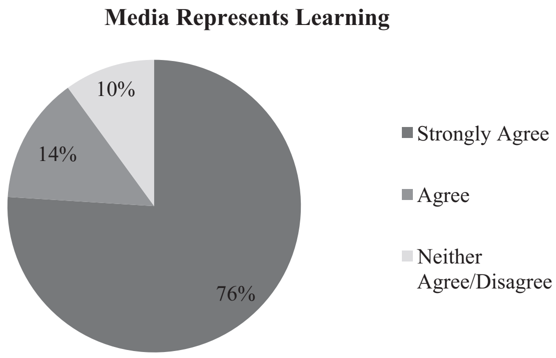


Fig. 7.3 Students perception that multimedia represents and demonstrates their level of learning in a course

to the reasoning behind the processes being modeled in the technology for educators course. Since the students are preservice teachers, it is important to not only subject them to the processes but also to explain to them the scope of intentional teaching practices.

Given that the course utilized in this study is heavily infused with large doses of pedagogy and content-knowledge instruction in addition to the technology literacy skill development, a balanced TPACK approach is modeled for the students. Furthermore, students are challenged to create outputs that equitably merge each TPACK component. It is important to point out, however, that a number of challenges must be addressed during a media-intensive performance pontification project: purposeful media use; tech glitches; students must learn tech in addition to content; tech resource availability (software and hardware); file size; students must get to the point in the limited time (think about a TV show); multimedia principles must be covered; and students could read their script without fully engaging in the content.

Aside from an instructional and learning tool, video has been around for many years as a formative assessment, feedback, and planning tool. Common uses in this realm have included recording oneself giving a speech or presenting a student teaching lesson, real-time and postgame sports analysis, diagnosis of medical conditions or behaviors, pretest and posttest analyses of research subjects, law enforcement, and anything that requires a comparative stop action, archival capability. From an instructor's point of view, the digital audio and video output can offer a creative and visual dimension not represented in print. From the student perspective, whereby they are interjecting an audible or visual presence in the media, it is typically more common as a self-assessment tool.

Video tools are not uncommon as a means to teach content to others, even with the self in the visual mix. Through the use of audio and video, students are able to solidify their learning due to the increased cognitive processing needed to develop quality output. In addition, students will encounter added motivation due to the prospect of having a novel means to demonstrate their competency. Students are fascinated (and thus motivated) by such tasks as having an Avatar represent themselves with their own voice and remotely similar appearance. As a demonstration of what one has learned based upon engagement in a course, digital audio and video in the online class environment is an underutilized and viable output. It warrants further analysis as an output tool not only in educational technology but also in less technology-focused disciplines as well.

Although students tend to like working with multimedia technologies in creating presentations as an alternative to prose output, the learning curve of the technologies adds more responsibilities to their shoulders. In a technology for educators course, it comes with the territory, but in other nontechnology related courses, low-tech options must be pursued. Lecture capture systems allow relatively low-tech alternatives, but the sacrifice is quality media presentation format and flexibility. It essentially becomes a talking head next to a PowerPoint presentation.

6 Assessing Massive Open Online Courses

Considering that the overall completion rate of MOOCs is noted to be in the 10% range (Kolowich 2013b) and that there is substantial interest in being able to offer these courses for credit, substantial advances in reliable assessment procedures need to be established. “Students who experience failure or disappointing grades carry negative emotions about their experience into their future learning” (Thorpe 1998, p. 268). The digital and other creative outputs discussed previously are simply not an option for courses enrolling tens to hundreds of thousands of students. Perhaps a categorization designation would be the first order of business to distinguish between credited open online courses (COOCs) and noncredited open online courses (NOOCs). The first could be tied to a highly weighted final examination proctored by colleges or by approved agencies that administer other certification exams. In this instance, it would act like the test-out option many disciplines maintain, except it would be supplemented by the remotely completed online summative assessments of questionable reliability. The second would be truly opening the doors of education to the world for anyone who purely wants to learn without credit or testing except as a means to reinforce learning via systematic quizzes.

7 Conclusion

Reliability issues in the online teaching front clearly need much more attention as we expand the online enrollments in courses. Offering proctored tests and test-out options is one solution, but not logistically feasible in many cases. Looking ahead, it would be beneficial to find out how many online courses are currently relying exclusively upon unmonitored online tests as the largest percentage of students’ final grades. There are elaborate organized schemes of online course assistance for students who are willing to pay, including test takers, paper writers, and entire course surrogate students. There are also plenty of honor-driven students, who complete their coursework via their own cognizance. They only want a better way to learn.

References

Airasian, P. W., & Russell, M. K. (2007). *Classroom assessment: Concepts and application* (6th ed.). New York: McGraw-Hill.

Arnold, S. D. (2010). *Student e-cooperative: Computer mediated group projects*. In the International Technology, Education, and Development Conference Proceedings CD (ISBN: 978-84-613-5538-9). Valencia, Spain: INTED.

Arnold, S. D., & Moshchenko, M. (2009). Technology input versus input and output: Does it result in learning differences among elementary school students? In C. D. Maddux (Ed.), *Research highlights in technology and teacher education 2009* (pp. 1–9). Chesapeake: Society for Information Technology & Teacher Education.

Arnold, S. D. (2012, October). Assessing online learning with digital audio and video. In Proceedings of World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education 2012 (pp. 473–479). Chesapeake, VA: AACE.

Brimi, H. M. (2011). Reliability of grading high school work in English. *Practical assessment Research & Evaluation, 16*(17), 1–12.

Calandra, B., Brantley-Dias, L., Lee, J. K., & Fox, D. L. (2009). Using video editing to cultivate novice teachers' practice. *Journal of Research on Technology in Education, 42*(1), 73–94.

Craik, F., & Lockhart, R. (1972). Levels of processing: A framework for memory research. *Journal of Verbal Learning and Verbal Behavior,* 11(6), 671–684.

Gronlund, N. E., & Waugh, C. K. (2009). *Assessment of student achievement* (9th ed.). Upper Saddle River: Pearson Education Inc.

Hunter, R. (2004). *Madeline Hunter's mastery teaching: Increasing instructional effectiveness in elementary and secondary schools*. Thousand Oaks: Corwin Press.

Kolowich, S. (22 March 2013a). The minds behind the MOOCs. The chronicle of higher education. http://chronicle.com. Retrieved October 1, 2013.

Kolowich, S. (8 April 2013b). Coursera takes a nuanced view of MOOC dropout rates. The chronicle of higher education. http://chronicle.com. Retrieved October 1, 2013

McKenzie, G. R. (1979). Effects of questions and test-like events on achievement and on-task behavior in a classroom concept learning presentation. *Journal of Educational Research, 72*(6), 348–351.

McMillan, J. H. (2011). *Classroom assessment: Principles and practices for effective standards-based instruction* (5th ed.). Boston: Pearson Education Inc.

McTighe, J. (1996). What happens between assessments? *Educational Leadership, 54*(4), 6–12.

Montgomery, K. (2002). Authentic tasks and rubrics: Going beyond traditional assessments in college teaching. *College Teaching, 50*(1), 34–39.

National Survey of Student Engagement [NSSE]. (2010). *Major differences: Examining student engagement by field of study-annual results 2010*. Bloomington: Indiana University Center for Postsecondary Research.

Popham, J. W. (2011). *Classroom assessment* (6th ed.). Boston: Pearson Education Inc.

Roblyer, M. D., & Doering, A. H. (2012). *Integrating educational technology into teaching* (6th ed.). Boston: Pearson Education Inc.

Roediger, H. L. III., Putnam, A. L., & Smith, M. A. (2011). Ten benefits of testing and their applications to educational practice. In J. P. Mestre & B. H. Ross (Eds.), *Psychology of learning and motivation* Academic Press, 2011, Volume 55, pp. 1–36, ISSN 0079-7421, ISBN 9780123876911, http://dx.doi.org/10.1016/B978-0-12-387691-1.00001-6.

Slavin, R. E. (2012). *Educational psychology: Theory and practice* (10th ed.). Boston: Pearson Education Inc.

Struyven, K., Dochy, F., Janssens, S., Schelfhout, W., & Gielen, S. (2006). The overall effects of end-of-course assessment on student performance: A comparison between multiple choice testing, peer assessment, case-based assessment and portfolio assessment. *Studies in Educational Evaluation, 32,* 202–222.

Swan, K., Schenker, J., Arnold, S., & Kuo, C.-L. (2007). Shaping online discussion: Assessment matters. E-mentor, 1 (18). http://www.e-mentor.edu.pl/_xml/wydania/18/390.pdf. Retrieved October 1, 2014.

Thorpe, M. (1998). Assessment and third generation distance education. *Distance Education, 19*(2), 265–286.

Tuckman, B. W. (1999). *Conducting educational research* (5th Ed.). Belmont: Wadsworth Group.

Watson, G., & Sottile, J. (2010). Cheating in the digital age: Do students cheat more in online courses? Online Journal of Distance Administration, 13 (1). http://www.westga.edu/~distance/ojdla/spring131/watson131.html. Retrieved October 1, 2013.

Williams, B. L., & Suen, H. K. (1998). Formal versus informal assessment methods. *American Journal of Health Behavior, 22*(4), 308–313.

Young, C. B., & Henquinet, J. A. (2000). A conceptual framework for designing group projects. *Journal of Education for Business,* 76(1), 56–60.

Chapter 8
Theorizing Why in Digital Learning: Opening Frontiers for Inquiry and Innovation with Technology

Jonathan Charles Mason

1 Introduction

In introducing any topic of investigation, it is usually helpful to understand *why* it is presented and what its key drivers are; a listener or reader often finds it helpful to understand the context of an investigation in order to make some initial sense prior to embarking on giving it further attention. Such a context can also be described in terms of motivation, purpose, rationale, and/or justification for the work—or as 'advance organizers' (Ausubel 1960). Perspectives that emerge from responding to questions can also help to establish context, for example:

1. Why is this chapter included in this current volume?
2. What is the central argument of this chapter?
3. How does this chapter connect with the theme of open access?

Providing perspective of this kind can serve as a trigger for cognitive engagement and doing so—in the form of a well-constructed abstract—is an established academic convention. Roots of influence for this practice stretch back to the time of Aristotle, when logos was elaborated as a well-formed argument based upon reason and, as such, one of three modes of persuasion—the others being ethos and pathos.

Thus, motivation for this chapter emerges from consideration of future prospects for digital learning activities that probe the *why dimension* of inquiry—asking, learning, understanding, knowing, and explaining *why*. In order to develop an overarching narrative, a number of interrelated topics are discussed: the evolution of digital learning and associated narratives that both describe and inform this, such as the 'open agenda'; the role of questioning while learning; descriptive versus explanatory content; inquiry-based learning; sense-making versus meaning-making during learning; scaffolding using information and communications technology (ICT); and future prospects for ICT tools that support and promote *why*-questioning.

J. C. Mason (✉)
Charles Darwin University, Ellengowan Drive, Brinkin, Australia
e-mail: jon.mason@cdu.edu.au

D. G. Sampson et al. (eds.), *Digital Systems for Open Access to Formal and Informal Learning,* 101
DOI 10.1007/978-3-319-02264-2_8, © Springer International Publishing Switzerland 2014

Following Piaget's (1966) seminal work on child development and related academic literature on the subject of the nature of learning, it is assumed that *asking why* is an important foundation of inquiry and fundamental to the development of reasoning skills (Piaget 1966; Dewey 1966; Vygotsky 1978; Paul and Elder (1999). In direct contrast, apart from some notable exceptions (ter Berg et al. (2009), sophisticated ICT tools that directly support this basic act of learning appear to be either undeveloped or, at best, in the very early stages of development. Why is this so? On the one hand, this chapter suggests there are a number of very good reasons; on the other, it is focused on the implications of developing innovative tools that support asking and understanding why and assist in sense-making during digital learning.

This chapter reports on findings from relevant research and practice with a view to informing the design of digital tools that might stimulate deep learning and cognitive engagement. In supporting a clear rationale for this theme, the following real-world scenarios are introduced to describe contemporary situations in digital learning involving concepts of why.

1.1 Scenario: University Student

Sarah is a university student majoring in international relations and history. She has opted to do much of her studies online because it provides her with the flexibility to take on some part-time work. The university has invested considerable funds into preparing appropriate content and assessment tasks for subjects offered in online mode; it has also implemented a standard single-platform policy and installed Blackboard, a learning management system that helps structure learning content and contain interactions between staff and students. Sarah uses Google to search for additional resources for an essay on the conflict in the Middle East. While she finds numerous resources, it is challenging for her to understand the causes of this conflict or what the appropriate actions might be for it to be resolved. The course resources seem well structured, but she is required to investigate sources beyond the prescribed texts. If she searches Google with '*why*' questions, she feels very dissatisfied with the quality of the results. Likewise, when searching the library catalogue, she is overwhelmed by the volume of resources and is not confident in making a judgement about *why* this conflict seems so deeply problematic because she finds so many plausible, yet contradictory, and politicized explanations. Even though she has access to a number of 'social software' applications that enable her to interact and share resources easily with others who might be investigating the same topic, she feels like there is something lacking in the online tools available. She feels that she needs assistance in discerning fact from political rhetoric and some other way of navigating and evaluating the large amount of content on this topic. She wants to *understand* the key issues at the heart of the conflict.

1.2 Scenario: High School Teacher

Dave is an art teacher at a high school with two decades of experience. The school has a reputation for adopting digital technologies into the curriculum wherever possible; however, art has been the last subject to embrace ICT. This is partly due to the fact that Dave feels more comfortable using traditional media. The school is now urging him to make the shift. In moving his content into an electronic mode, Dave discovers that he has to anticipate many of the questions that students typically ask in the classroom (‘*but why do we have to study Matisse, sir?*’, ‘*why is some abstract art seen as having great merit while some doesn't?*’, ‘*why are there different versions of what constitute primary colours?*’). Because of his experience, he knows that the students need good answers to such questions so that they can be motivated to learn. He thinks that he may need to create a bank of such questions together with suitable answers but hesitates because he knows that when students ask questions, a longer conversation often proceeds. He is unsure of the best way to make such information available, so he chooses just to make it explicit in the introductory text to each task described in the online version of his course. But he remains sceptical that anticipating such questions in a ‘canned’ way will be as motivating for the students as being able to respond in real time. He would prefer to foreground student questioning and make it stimulating and interactive, rather than content that students read.

1.3 Scenario: Instructional Designer

Thor is an instructional designer for a publishing company that specializes in demystifying science. The publisher has already had commercial success in preparing online materials that mimic the successful television series in Australia during the 1960s, ‘*Why is it so?*’ Thor has been asked to assist in developing innovative pathways to scientific content that will stimulate students to think and ask ‘*why*’, to motivate their curiosity that leads them into understanding scientific inquiry. He is not quite sure how to proceed and is suspicious of question-and-answer (Q&A) approaches, because providing answers can often close down inquisitiveness; he knows that powerful search engines like Google can deliver responses to search queries, but will also limit the student to searching, not *questioning,* he is also aware that none of the natural language search engines he knows of seem to do a very good job with responding to *why* questions. How is he to proceed?

1.4 Scenario: Teacher Librarian

Lisa is a teacher librarian. She has access to a range of repositories of high-quality, digital learning content. Most of this content is described using Dublin Core metadata (i.e. information such as the author, title, keywords, and abstract) and some of it is described by Institute of Electrical and Electronics Engineers (IEEE) Learning Object Metadata (i.e. information similar to Dublin Core metadata but also includes information about the educational level associated with the content and duration of the resource). Some resources also have metadata that describe associated learning objectives and competence level required in order to interact effectively with the resource. Lisa has found that many of the teachers she supports also want to know *why* a particular resource might be more suitable than another for a particular learning activity or goal. Lisa has found that rating systems and user-generated tags and 'folksonomies' are sometimes helpful in this regard, but is frustrated that not all the repositories support such services. She wonders whether there might be a better approach.

1.5 Scenario: Professional Psychologist

Susan is a psychologist who is diligent about continuing her professional learning. The focus of her work is on criminals, and she is interested in researching other practitioners' professional case notes to determine if there exists any variance between the explanations given by criminals as to reasons why crimes were committed and longitudinal research that explores motivational profiles of criminals in general. She is interested in utilising digital technology tools that might assist her in the retrieval and analysis of purely explanatory content. But how does she begin? She knows from experience during interviews that even when there is an explicit question of the nature 'please explain', important aspects of explanations often occur at other points in conversations. She is intrigued by explanations that indicate *why* a criminal act was committed.

1.6 Scenario: Lawyer

Stephan is a lawyer with an interest in differences between legal arguments that range across weak, plausible, and compelling. He is researching a large number of legal proceedings with a focus on the plausibility of explanations given by both the defence and the prosecution to determine what the 'tipping point' might be in determining the outcome—and when an explanation transitions from weak to plausible and plausible to compelling. He has already found that in cases involving juries, there are numerous factors that influence individual and group decision-making, and there is already a body of research on indicators such as demographic profile and family background. By focusing on explanations, Stephan wants to understand what the key indicators of plausibility might be, as he knows from experience that once plausibility is established, a key milestone is achieved in any argument. He is interested in finding out what kinds of digital tools might support him better than performing step-by-step searching.

2 Digital Learning Evolves

Having established some rationale for why ‘*why*’ represents an important topic for digital learning, the following discussion now turns to historical perspective as a means of contextualizing developments to date while pointing towards a frontier for further innovation. Numerous narratives concerning the digital revolution and its impact upon learning can be identified and often embrace concepts of convergence, disruption, transformation, as well as profound impact of networks and *open* technologies (Mason and Pillay 2014; Collis and Moonen 2002; Garrison 1997; Garrison 2011). This section outlines a number of these, highlighting that contemporary digital technologies are conducive to self-regulated, inquiry-based learning, and as a consequence, there exists an enormous scope for innovation that can support it.

2.1 E-Learning and Digital Learning

Theory and practice of any domain of human activity are constantly evolving and mutually informing. But while both philosophers and practitioners have discussed matters associated with *learning* for thousands of years, it is not yet two decades since the term ‘*e-learning*’ entered mainstream discourse. It is therefore important to make explicit what is meant by this term as it has been appropriated by diverse communities of practice since it first appeared around 1998–1999 (Cross 2004; CIPD 2008; Garrison and Anderson 2003). *Digital learning* is a more recent term and arguably has a broader long-term utility in that it comfortably describes learning facilitated by all kinds of technology devices, often built primarily for other purposes such as games for entertainment, mobile phones for communications, or navigation via global positioning systems. For the purposes of this chapter, these terms can be understood as broadly synonymous based upon current usage and in consideration that both terms will likely persist within the domain of learning, education, and training for quite some time.

The issue of terminology has other facets to it apart from utility, and these terms can signify both a theoretical discourse and a range of activities that take place in many contexts—formal and informal—within educational institutions and workplace settings, or elsewhere ‘*any time any place*’ as the saying goes. Adopters of these terms include corporate training associations, professional associations, academic web enthusiasts, government policymakers, software vendors, standards development organizations, and military organizations, just to name a few (Mason 2005, p. 320; ISO 2007; Marshall 2004). There are distinctions according to the context. For example, Bates (2004, p. 275) identifies key differences between post-secondary education and corporate settings—the latter being more concerned with the broader context of knowledge management, the former focused on learning and research. In an attempt to broaden philosophical perspective, Friesen (2009) puts the case for ‘rethinking e-learning research’ and argues for a ‘reconceptualization of e-learning as an inter- and cross-disciplinary endeavor’ (p. 20). Conceptualizing in even broader terms, Cooper argues that its scope of activity is best understood as 'emergent' and therefore subject to analyses that highlight perspectives on 'complexity' (Cooper 2010). Others prefer to use the related terminology '*online learning*' to frame the challenges of 'integrating technology into classroom instruction' (Tomei and Morris 2011). For the purposes of this chapter, *digital learning* and *e-learning* are defined as *learning facilitated by engagement with digital technology*.

2.2 Innovation and Practice

With the above definition in mind, the diversity of digital technologies developed over the past few decades can meaningfully be described as systems, environments, or services that support digital learning. Examples of *structured, contained,* or *purpose-built* platforms include computer-based training systems, learning management systems, intelligent tutoring systems, e-portfolio systems, performance support systems, virtual worlds, gaming environments, e-books, and other related applications and services. Anyone with a young child who has access to an iPad will also know how engaging and educational a single app can be—whether it is explicitly educational or not. Examples of *unstructured* and *open* environments that can function as digital learning environments include use of mainstream search engines and social media. Benefits and deficiencies can be identified with all of these developments, as is documented in the extensive and growing discourse on e-learning—for example, the number of peer-reviewed journals worldwide dedicated to the subject is now in excess of 50 titles, and the majority of these titles has emerged in the past 5 years. If related topics such as distance education, e-research, technology in society, knowledge creation, and performance support are included, then there are hundreds of relevant journals.

As digital learning develops into an established academic field, it brings with it a discourse that refines its core concepts and terms, while ICT innovations and trends evolve. It is also likely that certain trends and biases will be revealed along the way. For instance, evidence suggests that much of the first generation of practice associated with e-learning has been very focused on the delivery and access to *purpose-built learning content,* not so much with *learning activities* or the *cognitive processes* associated with learning (Dalziel 2003; Alonso et al. 2005; LETSI 2008; ADL 2009). This first generation of learning content has also been constrained by metadata that are *descriptive* in function and used for the management and discovery of content—in other words, metadata that describe the content in terms of semantics that can be shown to be facets of *who, what, when,* and *where* information.

It is also the case that the educational potential of existing, emerging, and future developments in digital technology is now commonly discussed in a growing diversity of settings (daily newspapers, school curriculum support materials, political party policy documents, workplace human resource departments, standards-setting bodies, academic literature, and in higher education strategic planning). The '*digital education revolution*' policy of the Australian government during 2007–2010 is a prominent example of a public policy response (DEEWR 2008;). Such a public policy has been commonplace since the invention of the World Wide Web, although prior to this, the transformative potential of educational technology was recognized at various other historical moments (such as with the inventions of radio, television, personal computers, interactive, and game-based digital media).

There are therefore multiple perspectives that help explain the history and viable developmental paths of digital learning into the future. Innovation with technology, however, does not necessarily render earlier technologies redundant. For example, the Australian *School of the Air*, which began as a dedicated radio broadcast in 1951 and continues today in servicing the needs of remote communities in Australia, represents an example of an older communications technology that is still used effectively for educational purposes. Likewise, innovation in pedagogical practice does not necessarily render older techniques irrelevant, and this is borne out by the persistence of Socratic questioning in contemporary teaching practice aimed at developing critical thinking skills (Paul and Elder 2007a, b).

2.3 Historical and Social Narratives

A broader historical perspective provides further context. Not only has evolution of the World Wide Web taken place within a short period of time accompanied by rapid innovation, it has also been *transformative,* representing a global revolution in the production, distribution, and access to information and communications through informational and social networks (Castells 1996; Benkler 2006; Gleick 2011).

As a consequence of these developments, numerous commentators have introduced narratives on the transformative impact upon teaching and learning (Greenhow et al. 2009). Taylor (2001), for instance, began visioning 'fifth-generation distance education' around 2001–2002 as an 'intelligent flexible learning model'—bringing together the concept of '*flexible delivery*' with a student-centric approach, this conception also described the organizational structures and readiness for institutions concerned. In 2005, Siemens proposed a new learning theory called 'connectivism', motivated principally by the impact of the proliferation of networked ICT applications and the limitations of dominant learning theories (behaviourism, cognitivism, and constructivism) to explain and support the scope of interactions available to a learner. The distinguishing characteristic of Siemens' theory is the prominent role of networks in creating connections between disparate learning sources and events (Siemens 2005). Siemens' work resonates with the extensive sociological work of Castells (1996, 2001) in outlining the 'rise of the network society' and in the work of Benkler on the social production of intellectual capital (Benkler 2006).

More recently, there has been popular usage of the terminology 'Web 2.0' typically to describe networking capabilities that leverage social media providing individuals with an enormous scope for publishing content and social interaction. Adoption of such a terminology has also led to characterizations of 'Learning 2.0' being learning that is facilitated by Web 2.0 social media applications (Alexander 2006; Brown and Adler 2008) and related commentary about the 'post-LMS era'

(Mott 2010) and Web 3.0 (Hendler 2009; Sutter 2009; Wiktionary 2013). The utility of such characterizations is yet to be determined; however, in terms of the evolution of digital learning, they can be somewhat misleading because they mask, or do not always explicitly acknowledge, the capabilities that already existed in early phases of development—such as in computer-based training (CBT), computer-assisted learning (CAL), computer-managed learning (CML), computer-mediated Communication (CMC), and computer-supported collaborative learning (CSCL).

The important observation here is that there are numerous technologies that have shaped what digital learning is today. Secondly, and most importantly for the theme of this chapter, none of the innovations mentioned hitherto have explicitly explored how *why*-questioning during learning might be explored or supported with digital technology.

2.4 Openness and Education

Informing the narratives associated with the evolution of digital learning is the underlying history of '*open*' technologies that have shaped the Internet (Leiner et al. 2009). Following Leeson and Mason (2007), a construct termed the 'open agenda' can be used to summarize a number of trends concerned with openness in education that have developed in parallel to the evolution of digital learning. This agenda can be seen as reaching across both formal and informal learning contexts and includes notions of free access to content, no prerequisites for course entry, non-restrictive intellectual property licensing, public benefit, and technical interoperability (Mason and Pillay 2013). Recent mainstreaming of this agenda finds expression in the rapid success of massive open online courses (MOOCs), although such developments also bring with them debates about the nature of openness (Yuan and Powell 2013, p. 16; Downes 2013; McGreal et al. 2013; Daniel 2012; Pappano 2012).

Concepts associated with openness and education, however, have roots that predate the Internet era and can be linked with contributions made to educational theory by Dewey (1910) and Montessori (1949) in which openness is associated with a student-centred approach to learning that is inquiry based, not constrained by specific content, or prescribed by specific learning outcomes. It is argued here, therefore, that the 'open agenda' is a natural place to reposition development of inquiry-based learning into the future—thereby broadening the agenda beyond issues of access, licensing, enrolment, and technical interoperability to also embrace processes of inquiry. The following section on positioning for the future elaborates further.

2.5 Into the Future

With the foundations of digital learning now well established, there is enormous scope for new developments that may enrich learning experiences through supporting deeper *inquiry* and cognitive engagement via environments that stimulate reflective and dialogic practice and support the development of *understanding* while learning online. A number of likely future trajectories can be discerned from the current context. For example, the broad uptake of social media provides ongoing stimulus for the use of diverse collaborative environments at scales unprecedented, and with the change in millennium, the idea of 'twenty-first-century skills' has emerged as more important than content knowledge—skills that place emphasis upon digital literacies, critical thinking, and problem-solving in equal measure (Kuhlthau 2004; Griffin et al. 2012; Casey and Bruce 2011). Other developments will emerge as a consequence of ubiquitous broadband connectivity, innovations in natural language search technologies, access to open educational resources, proliferation of mobile technologies, mainstreaming of work-integrated learning programmes, and innovation with intelligent tutoring systems. As the discourse develops, debates also arise, such as whether 'IT' develops further as an 'intelligent technology' or an 'interruption technology' (Carr 2010)? No doubt, unexpected innovations will also impact the evolutionary story and both options are plausible.

This chapter, however, is concerned with *one* of the frontiers that beckon further development—digital technologies that support deep learning instigated by *why*-questioning, reflective practice, and promote cognitive engagement (Mason 2012, 2011a). Through an analysis of the activities associated with the *why dimension*—asking, learning, understanding, knowing, and explaining *why*—there appears to be scope for a genre of technologies described as *sense-making technologies* (Mason 2013) that would complement the *semantic technologies* often associated with the emergence of Web 3.0 (Hendler 2009; Sutter 2009; Wiktionary 2013). There are a number of reasons for this, as will be outlined in the next section, but arguably the most significant is that the *why dimension* is concerned with *explanatory,* in contrast to *informational,* content. As such, it is related to content that typically requires reasoning skills and sense-making in order to achieve understanding and facilitate learning. In contrast, semantic technologies are focused on parsing semantics and the construction of meaning; however, as will be shown, *why* is a word that carries ambiguous semantics and sense-making has been shown to precede meaning-making (Mason 2013).

3 Cognitive Engagement

This section now turns to issues related to engaging with digital technology for the primary purpose of learning. It assumes that learning is typically more conducive to taking place when the mind is focused and engaged, allowing for reflection and attentive dialogue.

3.1 Ubiquitous Distraction?

There can be little doubt that the Internet has spawned a proliferation of ICT tools useful for learning. But the story of the impact of such relentless innovation is not an intrinsically positive one. It is also accompanied by a growing discourse arguing that extended use of the Internet can have detrimental effects on cognition and behaviour (Clark 2002; Bannister and Remenyi 2009; Carr 2010; Aguirre 2011; Chalupa 2011). Evidence shows that there is definitely an impact upon *cognitive load* (Verhoeven 2009; Kleinberg 2011), a topic that instructional designers have been concerned with for decades (Sweller 1994). For example, for reasons that being online can be very distracting with the effect of weakening cognitive focus, the term 'interruption technology' has been a catch phrase in contemporary popular commentary on the Internet:

> the single most mind-altering technology that has ever come into general use…when we go online, we enter an environment that promotes cursory reading, hurried and distracted thinking, and superficial learning…. The Net's cacophony of stimuli short-circuits both conscious and unconscious thought, preventing our minds from thinking either deeply or creatively. (Carr 2010)

Of course, similar commentary and research have existed for decades about extended exposure to television and virtual gaming environments. Thus, the discourse is not all negative—for example, research shows that while extended Internet use can cause some loss of short-term memory, there is also a gain in that 'The Internet has become a primary form of external or transactive memory, where information is stored collectively outside ourselves' (Sparrow et al. 2011).

There is truth in both arguments—so in terms of the nature of cognitive engagement while learning online, evidence that drives this debate will be important for researchers to track. This issue is introduced here because *why*-questioning requires focus in order to proceed.

3.2 The Search Paradigm

The enormous market success of the Google search engine can be seen as paradigm shaping in the way that much learning online and scholarship are now initiated—via *search*. This is true in both formal and informal learning contexts. Of course, not all search requests using Google are concerned with learning and most are better classified as *information seeking*. But the significance of Google's innovation is that its search engine's functionality has also delivered routine information retrieval and discovery into the mainstream impacting corporate workflows, the socialization of information (Brown and Duguid 2000), government-based services, and the expectations of citizens of the developed world. Moreover, as Google (the company) has developed its own services, such as *Gmail, Google Docs,* and *Drive,* the flagship search engine can be seen as the core piece of technical architecture—*search* being the key operator on, and organizing technology for, *content*. Again, however, Carr (2010) notes a downside:

> Google…shapes our relationship with the content that it serves up so efficiently and in such profusion. The intellectual technologies it has pioneered promote the speedy, superficial skimming of information and discourage any deep, prolonged engagement with a single argument, idea, or narrative. 'Our goal,' says Irene Au [from Google], 'is to get users in and out really quickly. All our design decisions are based on that strategy.' (p. 156)

The immediate counterpoint to this argument is that innovations in ICT are far richer than the Google suite of services. But, there is a further issue with the search paradigm relevant here: Google's search engine is calibrated with a design bias that privileges the *aboutness* of content—in other words, it is focused on parsing *information* as *data*. Its internal indexes are all built on data that are *factual* and *measurable*, and searches are typically instigated by keywords and phrases, *not questions* constructed in natural language. Thus, interactions with Google can be seen as being constrained by 'factoid' information (Verberne 2010), or what has been described as the 'primitives of information-retrieval'—facets of information that are readily associated with questions of *who, what, when,* and *where* (Mason 2008). While Google uses sophisticated algorithms involving various weightings associated with 'backlinks', this still functions as factoid information. Even with value-added services to Google search, such as ManagedQ, results to queries are organized into sets associated with people (*who*), things (*what*), and places (*where*). This underlying constraint has the effect of 'information begetting information' and interrupts prolonged inquiry or direct pathways into the discovery of content that is *explanatory* in nature (Mason 2008; 2011a). This does not mean that explanatory content is not retrieved, just that it is not easily or directly discovered. In particular, queries that are conceived with '*why*' in mind are not parsed well by Google because of the semantic ambiguity and linguistic versatility of the term *why* (Evered 2005; Verberne 2010; Mason 2008). This has significant repercussions for the design of ICT systems aimed at supporting learning.

3.3 Dimensions of **Why**

Why distinguishes itself from other 'primitive' questions (*who, what, when, where,* and *how*), in that it often requires a plausible *explanation* or rationale as an adequate response—in other words, reasoning as well as information (Verberne 2010, p. 10). Thus, *why*-questioning has the potential to initiate a shift from information processing to engagement of other cognitive functions, such as inquiry, analysis, problem-solving, and reflection. And more than the other primitive questions, as Walton (2004) has noted, *why* acts as a key initiator of dialogue.

For researchers pursuing question-generation techniques in intelligent tutoring, *why* questions are seen to belong to a 'deep/complex' category of all possible question types (Graesser et al. 2007). Evered (2005) provides an analysis in which the function of responses to *why*-questioning is categorized according to three classes of explanation: causal (*Why E? Because C* (*C*=cause)), teleological (*Why E? In order to P* (*P*=purpose)), and gestaltic (*Why E? For these reasons*, *R* (*R*=reasons); Evered 2005, p. 201). Thus, in identifying opportunities for innovation with digital technologies that might support inquiry and reflection, access to and production of *explanatory* content, as distinct from *descriptive* content, are of prime concern here.

Additional complexity also arises as a consequence of the linguistic versatility of *why* (Mason 2011a, p. 93). Because of this versatility, *why* is not regarded as a 'semantic prime' by linguists developing natural semantic metalanguage (research that is focused on identifying concepts with irreducible semantics across all natural languages). To qualify as a semantic prime, a concept and its associated terms must be free from ambiguity (Goddard and Wierzbicka 2007).

Thus, in probing the linguistic functions of *why,* five key activities can be identified—asking, learning, understanding, knowing, and explaining *why*—and common to all these functions is reasoning. The literature on educational psychology tells us that *asking why* is an important foundation of inquiry and fundamental to the development of reasoning skills and learning (Dewey 1966; Piaget 1966; Schank and Cleary 1995; Bruce and Casey 2012). Processes of *learning, understanding,* and *knowing why* build upon inquiry and sense-making and all are sustained by reflective practice (Schön 1987, p. 72). After learning something, *explaining why* can reveal a person's understanding or knowledge (or lack of it). A summary of the key aspects of each of the five activities associated with the *why dimension* is as follows:

- *Asking why* is concerned with sense-making and critical thinking
- *Learning why* invokes reasoning skills
- *Understanding why* constructs plausible conceptualizations
- *Knowing why* rationalizes plausible conceptualizations
- *Explaining why* enables dialogue and story and elaborates upon plausibility

Thus, a question arises as to what digital technologies—as applications, services, or interventions—might support inquiry instigated by *why*-questioning and other activities associated with the *why dimension*? Such a question points to a frontier ready for development. It is a question of access that is broader in scope than issues of licensing and cost that dominate contemporary notions of open access (Vollmer 2012).

3.4 *Questioning and Reflective Practice*

Investigations into contemporary digital technologies that explicitly aim to support *why*-questioning reveal some search technologies based upon natural language processing and computational linguistics, although findings to date demonstrate that much research is yet to be done (Ferrucci et al. 2010; Verberne 2010). Research is also proceeding in the fields of information science (metadata schemas and question–answer techniques) and question generation for intelligent tutoring (Kunze 2001; Mason 2008; Rus and Graesser 2008). Of immediate relevance, however, is the further application of wikis and e-portfolio systems to support reflective and dialogic practice that is consistent with the goals of inquiry-based learning. Evidence is mounting that both approaches—one via the route of enlisting open, social engagement in content production (wikis), the other, individually controlled reflective journalism that is discretionally shared—develop reflective practice and therefore prolonged cognitive engagement (Loo 2012; Mason 2011b). A challenge, then, that is specific to the focus of this chapter is *how* digital technologies might leverage these platforms.

4 Consequences

Investigations into *why*-questioning reveal that there are significant repercussions for the design, development, and utilization of digital technologies aimed at supporting learning. In particular, accommodating multiple dimensions of *why*—asking, learning, understanding, knowing, and explaining—points to frontiers of inquiry that will need to draw upon *explanatory* content and prolonged cognitive engagement through reflective practice. Importantly, such technologies will need to move beyond the current constraints of the *search paradigm* and provide support for sense-making and reasoning.

While the semantic ambiguity associated with *why* presents challenges for semantic technologies, this limitation suggests a counterpoint, and the concept of *sense-making technologies* has been introduced to describe technologies that might directly support the *why dimension.* It will be through innovation that the efficacy of this argument will achieve validation.

A further consequence of this chapter is the distinction made between *sense-making* and *meaning-making,* an important construct in the literature associated with constructivism and 'meaning-centred education' (Kovbasyuk and Blessinger 2013; Jones and Brader-Araje 2002; Hein 1999; Jonassen et al. 1995). *Why* is this distinction made? In many contexts, it would seem that these terms could be used interchangeably—for example in understanding how to respond when driving a car and approaching a red light: Making sense of this situation and understanding the meaning of a red light are one and the same. In situations involving more complexity, such as discerning the intent of statutory legislation concerning the pricing of carbon, to make sense of the documentation requires reasoning while the meaning of such a document might simply be discerned as a mechanism to ameliorate climate change. Another example is in the use of abstract models as a means of communication required for expressing more complexity than the semiotics of a conventionally accepted symbol, such as an exit sign. Understanding the full implications of a model may require extended reflection and reasoning, while the meaning of such a model may just be that it is an abstract representation. Thus, in such contexts, meaning is not necessarily ascribed in the process(es) of sense-making nor essential to it; conversely, however, sense-making seems to be an essential activity when the *why dimension* is invoked. This is the case because the object that *why*-questioning seeks is not so much concerned with any meaning that can be inferred from *information,* but more with developing *understanding* of an *explanation* or rationale that might typically form a response.

In presenting the *why dimension* and its association with digital-enabled inquiry-based learning, this chapter also points to a conception of *access* that is broader in scope than issues of licensing and cost that dominate contemporary notions of *open access*. Indeed, as the *Macquarie Dictionary* (Butler et al. 2011) indicates, one of the many meanings of *open* is 'to render accessible to knowledge' (p. 881). Through innovation with digital technologies, then, inquiry may find new openings.

References

ADL (2004). *Sharable Content Object Reference Model* (*SCORM*) 4th Edition. Advanced Distributed Learning, US Department of Defense. Retrieved November 16, 2013 from http://www.adlnet.gov/Technologies/scorm/default.aspx.

Aguirre, A. (2011). The enemy of insight? In J. Brockman (Ed.), *Is the internet changing the way you think? The net's impact on our minds and future* (pp. 304–306). New York: Harper Perennial.

ADL (2009). SCORM 2004 4th Edition: Overview. Retrieved November 16, 2013 from http://www.adlnet.gov/Technologies/scorm/SCORMSDocuments/2004%204th%20Edition/Overview.aspx

Alexander, B. (2006). Web 2.0: A new wave of innovation for teaching and learning? *Educause Review*, *41*(2), 32–44. Retrieved August 16, 2013 from http://net.educause.edu/ir/library/pdf/ERM0621.pdf.

Alonso, F., et al. (2005). An instructional model for web-based e-learning education with a blended learning process approach. *British Journal of Educational Technology, 36*(2), 217–235.

Ausubel, D. P. (1960). The use of advance organizers in the learning and retention of meaningful verbal material. *Journal of Educational Psychology, 51*(5), 267–272.

Bates, T. (2004). The Promise and Myths of e-learning in Post-Secondary Education. In M. Castells (Ed.) *The Network Society: A Cross-cultural Perspective* (pp. 271–292). Cheltenham, UK: Edward Elgar. Retrieved December 15, 2014 from http://www.tonybates.ca/wp-content/uploads/2008/07/castell4.pdf.

Bannister, F., & Remenyi, D. (2009). Multitasking: The uncertain impact of technology on knowledge workers and managers. *The Electronic Journal Information Systems Evaluation, 12*(1), 1–12.

Benkler, Y. (2006). *The wealth of networks: how social production transforms markets*. USA: Yale University Press.

Brown, J. S., & Duguid, P. (2000). *The social life of information*. Boston: Harvard Business School Press.

Brown, J. S., & Adler, R. P. (2008). Minds on fire—open education, the long tail, and learning 2.0. *Educause Review, 43*(1), 17–32.

Bruce, B. C., & Casey, L. (2012). The practice of inquiry: A pedagogical 'sweet spot' for digital literacy? *Computers in the Schools, Special Issue on Signature Pedagogies, 29*(1–2), 191–206.

Butler S., Atkinson A., & Moore A. (2011). *Macquarie Encyclopedic Dictionary*. Sydney: Australia's Heritage Publishing.

Carr, N. (2010). *The shallows—what the internet is doing to our brains*. New York: Norton.

Casey, L., & Bruce, B. (2011). The practice profile of inquiry: Connecting digital literacy and pedagogy. *E-Learning and Digital Media, 8*(1):76–85.

Castells, M. (1996). *The rise of the network society—the information age: Economy, society and culture* Vol. I. Oxford: Blackwell.

Castells, M. (2001). *The internet galaxy—reflections on the internet, business, and society*. Devon: Oxford University Press.

Chalupa, L. (2011). The greatest detractor to serious thinking since television. In J. Brockman (Ed.), *Is the internet changing the way you think? The net's impact on our minds and future* (p. 44). New York: Harper Perennial.
CIPD (2008). E-learning: progress and prospects. Chartered Institute of Personnel and Development, UK. Retrieved, August 8, 2013 from https://www.cipd.co.uk/hr-resources/factsheets/e-learning.aspx.
Clark, D. (2002). Psychological myths in e-learning. *Medical Teacher, 24*(6), 598–604.
Collis, B., & Moonen, J. (2002). Flexible learning in a digital world. *Open learning, 17*(3), 217–230.
Cooper, A. R. (2010). Key challenges in the design of learning technology standards: Observations and proposals. *International Journal of IT Standards and Standardization Research, 8*(2), 20–29.
Cross, J. (2004). A history of eLearning, the future of eLearning, internet time group. Retrieved August 8, 2013 from http://www.scribd.com/doc/12913198/History-Future-of-eLearning-On-the-Horizon.
Dalziel, J. (2003). From re-usable e-learning content to re-usable learning designs: Lessons from LAMS. Retrieved August 8, 2013 from http://www.lamsinternational.com/CD/html/resources/whitepapers/Dalziel.LAMS.doc.
Daniel, J. (2012). Making sense of MOOCs: Musings in a maze of myth, paradox and possibility. *Journal of Interactive Media in Education*, *3*. Retrieved December 10, 2013 from http://www-jime.open.ac.uk/jime/article/view/2012-18.
DEEWR (2008). Achieving a national vision for ICT in schools: Strategic plan to guide the implementation of the digital education revolution and related initiatives. Department of Education, Employment, and Workplace Relations (DEEWR), Australian Government. Retrieved August 8, 2013 from http://foi.deewr.gov.au/system/files/d11_210892_digital_education_revolution_strategic_plan20110419.pdf.
Dewey, J. (1910). *How we think: Restatement of the relation of reflective thinking to the educative process*. Republished edition, 2008. New York: Cosimo Books.
Dewey, J. (1966). *Democracy and education: An introduction to the philosophy of education*. New York: Free Press.
Downes, S. (2013). The role of open educational resources in personal learning. In R. McGreal, W. Kinuthia, & S. Marshall (Eds.), *Open educational resources: Innovation, research and practice* (pp. 207–221). Vancouver: Commonwealth of Learning.
Evered, R. (2005). A typology of explicative models. In C. Lundberg & C. Young (Eds.), *Foundations for inquiry: Choices and tradeoffs in the organizational sciences*. Stanford: Stanford Business Books.
Ferrucci, D., et al. (2010). Building Watson: An overview of the DeepQA project. *AI Magazine, 31*(3), 59–79.
Friesen, N. (2009). *Re-thinking E-learning research: Foundations, methods, and practices*. *Counterpoints—Studies in the postmodern theory of education, 333*. New York: Peter Lang Publishing.
Garrison, D. R. (1997). Self-directed learning: Toward a comprehensive model. *Adult Education Quarterly, 48*(1), 18–33.
Garrison, D. R. (2011). *E-learning in the 21st century: A framework for research and practice* (2nd ed). New York: Routledge.
Garrison, D. R., & Anderson, T. (2003). *E-learning in the 21st century: A framework for research and practice*. New York: Routledge/Falmer.
Gleick, J. (2011). *The information—a history, a theory, a flood*. New York: Pantheon.
Goddard, C., & Wierzbicka, A. (2007). Semantic primes and cultural scripts in language learning and intercultural communication. In G. Palmer & F. Sharifian (Eds.), *Applied cultural linguistics: Implications for second language learning and intercultural communication*. Amsterdam: John Benjamins.
Graesser, A., Rus, V., & Cai, Z. (2007). *Question classification schemes*. University of Memphis, USA. http://www.cs.memphis.edu/~vrus/questiongeneration/16-GraesserEtAl-QG08.pdf.

Greenhow, C., Robelia, B., & Hughes, J. E. (2009). Learning, teaching, and scholarship in a digital age Web 2.0 and classroom research: What path should we take now? *Educational Researcher, 38*(4), 246–259.
Griffin, P. E., MacGaw, B., & Care, E. (Eds.). (2012). *Assessment and teaching of 21st century skills*. Springer.
Hein, G. (1999). Is meaning making constructivism? Is constructivism meaning making? *The Exhibitionist, 18*(2), 15–18.
Hendler, J. (2009). Web 3.0 emerging. *Computer 0018–9162/09*, 88–90. http://files.myopera.com/NileshKumar/blog/Web%203.0%20Emerging.pdf.
ISO (2007). *ISO 860:2007–11 (E) Terminology work—Harmonization of concepts and terms*. International Organization for Standardization. http://www.iso.org/iso/catalogue_detail.htm?csnumber=40130.
Jonassen, D., Davidson, M., Collins, M., Campbell, J., & Haag, B. B. (1995). Constructivism and computer- mediated communication in distance education. *American Journal of Distance Education, 9*(2), 7–26.
Jones, M. G., & Brader-Araje, L. (2002). The impact of constructivism on education: Language, discourse, and meaning. *American Communication Journal, 5*(3), 1–10.
Kleinberg, J. (2011). The human texture of information. In Brockman J. (Ed.), *Is the internet changing the way you think? The net's impact on our minds and future* (pp. 83–85). New York: Harper Perennial.
Kovbasyuk, O., & Blessinger, P. (Eds.). (2013). *Meaning-centered education: International perspectives and explorations in higher education*. New York: Routledge.
Kuhlthau, C. (2004). *Seeking meaning: A process approach to library and information services*. London: Libraries Unlimited.
Kunze, J. (2001). *A metadata kernel for electronic permanence*. Proceedings of the International Conference on Dublin Core and Metadata Applications DC-2001. Retrieved January 10, 2014 from http://www.nii.ac.jp/dc2001/proceedings/product/paper-27.pdf.
LETSI (2008). *SCORM 2.0 White Papers*. Learning Education and Training Systems Interoperability initiative. Retrieved August 10, 2012 from http://wiki.letsi.org/display/nextscorm/SCORM+2.0+White+Papers.
Leeson, J., & Mason, J. (2007). *The open agenda and organisational alignment*. Supplementary Proceedings, the 15th International Conference on Computers in Education (ICCE 2007). 1, 189–194. Retrieved September 10, 2013 from http://www.intercog.net/publications/20071105_ICCE_Leeson_Mason.pdf.
Leiner, B. M., Cerf, V. G., Clark, D. D., Kahn, R. E., Kleinrock, L., Lynch, D. C., Postel, J., Roberts, L. G., & Wolff, S. (2009). A brief history of the internet. *ACM SIGCOMM Computer Communication Review, 39*(5), 22–31.
Loo, T. (2012). *Wikipedia in the Classroom*. Retrieved August 10, 2012 from http://niche-canada.org/node/10397.
Marshall, S. (2004). *E-learning standards: Open enablers of learning or compliance strait jackets*. In Beyond the comfort zone: Proceedings of the 21st ASCILITE Conference (pp. 596–605). Retrieved June 12, 2012 from http://www.ascilite.org.au/conferences/perth04/procs/pdf/marshall.pdf.
Mason, J. (2005). From e-learning to e-knowledge. In M. Rao (Ed.), *Knowledge management tools and techniques* (pp. 320–328). London: Elsevier.
Mason, J. (2008). *A model for sense-making: Exploring why in the context of learning and knowing*. Proceedings of the 16th International Conference on Computers in Education (pp. 545–549), Asia-Pacific Society for Computers in Education, Taipei, Taiwan.
Mason, J. (2011a). Cognitive engagement and questioning online. In A. Méndez (Ed.), *Education in a technological world: Communicating current and emerging research and technological efforts* (pp. 90–99). Badajoz: Formatex.
Mason, J. (2011b). *Scaffolding for integrated reflection*. Proceedings of the 19th International Conference on Computer in Education (pp. 587–594). Asia-Pacific Society for Computers in Education. Chiang Mai, Thailand.

Mason, J. (2012). Scaffolding reflective inquiry—enabling w*hy*-questioning while e-learning. *Research and Practice in Technology Enhanced Learning, 7*(3), 175–198. Asia-Pacific Society for Computers in Education (APSCE). Retrieved February 10, 2013 from http://www.apsce.net/RPTEL/RPTEL2012NovIssue-Article3_pp175-198.pdf.
Mason, J. (2014). The *why* dimension, dialogic inquiry, and technology supported learning. In S. Feller & I. Yengin (Eds.), *21st century education: Constructing meaning and building knowledge in technology supported learning environments*. Singapore: John Benjamins.
Mason, J., & Pillay, H. (2013). Opening digital learning to deeper inquiry. In M. Ally & B. Khan (Eds.), *The international handbook of e-learning*. Canada: Athabasca University.
McGreal, R., Kinuthia, W., & Marshall, S. (Eds.), (2013). *Open educational resources: Innovation, research and practice*. Vancouver: Commonwealth of Learning.
Montessori, M. (1949). *The absorbent mind* (Claremont, C., trans.). (original publication 1967). New York: Dell Publishing.
Mott, J. (2010). Envisioning the post-LMS era: The open learning network. *Educause Quarterly, 22*(1): 1–9.
Pappano, L. (2012). The year of the MOOC. *The New York Times, 2*(12), 2012. Retrieved January 10, 2014 from http://www.nytimes.com/2012/11/04/education/edlife/massive-open-online-courses-are-multiplying-at-a-rapid-pace.html
Paul, R., & Elder, L. (1999). Critical thinking handbook: Basic theory and instructional structures. Dillon beach: Foundation for critical thinking. Retrieved January 10, 2014 from http://www.criticalthinking.org/pages/the-role-of-questions-in-teaching-thinking-and-learning/521.
Paul, R., Elder, L. (2007a). Critical thinking: The art of Socratic questioning, Part I. *Journal of Developmental Education, 31*(1), 36–37.
Paul, R., & Elder, L. (2007b). Critical thinking: The art of Socratic questioning, Part III. *Journal of Developmental Education, 31*(3), 34–35.
Piaget, J. (1966). *The child's conception of physical causality*. London: Routledge and Kegan Paul.
Rus, V., & Graesser, A. (Eds.) (2008). The question generation shared task & evaluation challenge workshop report. University of Memphis. Retrieved August 10, 2012 from http://www.questiongeneration.org/.
Schank, R., & Cleary, C. (1995). *Engines for education*. New Jersey: Erlbaum.
Schön, D. (1987). *Educating the reflective practitioner*. San Francisco: Jossey-Bass.
Siemens, G. (2005). Connectivism: A learning theory for the digital age. Retrieved August 12, 2012 from http://www.elearnspace.org/Articles/connectivism.htm.
Sparrow, B., et al (2011). Google effects on memory: Cognitive consequences of having information at our fingertips. *Science 1207745*. doi:10.1126/science.1207745.
Sutter, J. (2009). *What is 'Web 3.0,' and should you care?* CNN SciTech. Retrieved January 10, 2014 from http://scitech.blogs.cnn.com/2009/05/25/what-is-web-3-0-and-should-you-care/.
Sweller, J. (1994). Cognitive load theory, learning difficulty, and instructional design. *Learning and Instruction, 4*(4), 295–312.
Taylor, J. C. (2001). Fifth generation distance education. Australian Department of Education, Training and Youth Affairs, Higher Education Division, Higher Education Series, Report No. 40, Canberra, Australia.
ter Berg, T., van Gelder, T., Patterson, F., & Teppema, S. (2009). *Critical thinking: reasoning and communicating with rationale*™. Amsterdam: Pearson Education Benelux.
Tomei, L. A. & Morris, R. (2011). Top technologies for integrating online instruction. *International Journal of Online Pedagogy and Course Design, 1*(1), 12–28.
Verbene, S. (2010). *In search of the why: Developing a system for answering why-questions*. Doctoral Dissertation, Radboud Universiteit, Nijmegen, The Netherlands Retrieved August 10, 2012 from http://repository.ubn.ru.nl/handle/2066/76174.
Verhoeven L. (2009). Cognitive load in interactive knowledge construction. *Learning and Instruction, 19*(5): 369–375.
Vollmer, T. (2012). Paris Declaration. CC Europe urges European Commission to support Open Education. Retrieved August 12, 2012 from http://creativecommons.org/tag/paris-declaration.

Vygotsky, L. (1978). Retrieved December 10, 2013 from *Mind in society*. Cambridge: Harvard University Press.

Walton, D. (2004). A new dialectical theory of explanation. *Philosophical Explorations: An International Journal for the Philosophy of Mind and Action, 7*(1), 71–89.

Wiktionary (2013). Web 3.0. http://en.wiktionary.org/wiki/Web_3.0.

Yuan, L., Powell, S. (2013). *MOOCs and open education: Implications for higher education*. Joint Information Systems Council (JISC) & Centre for Educational Interoperability Standards (CETIS). Retrieved December 12, 2013 from http://www.smarthighered.com/wp-content/uploads/2013/03/MOOCs-and-Open-Education.pdf.

Part II
Open Access to Formal and Informal Learning: Methods and Technologies

Chapter 9
Mobile Language Learners as Social Networkers

A Study of Mobile Language Learners' Use of LingoBee

Emma Procter-Legg, Annamaria Cacchione, Sobah Abbas Petersen and Marcus Winter

1 Introduction

Social networks, crowdsourcing and open access to learning have recently received a lot of attention in the area of technology-enhanced learning and have moved over into hot topics of conversation within the wider educational community. These ideas have introduced new concepts along with ideas of learning as a social activity and communities of learners (Haythornwaite 2011). Learners who already engage with social networks, such as Facebook and Twitter, and accept that they live their lives in the "social age" with the public or openness that goes with it (Jarvis 2011), expect similar capabilities in their learning environments, sometimes even expecting the learning processes to be connected in some way to their social networks. With the rise of massive open online courses (MOOCs) and the role that social media takes in this new style of learning, more and more educators and learners are seeing the potential of social media to aid learning. There has also been a rise in the didactic use of social media to engage learners in the learning process, helping them to become more active participants in their own learning experiences. This opens up a whole new dimension to the evaluation of learning and learning processes, drawing on

E. Procter-Legg (✉)
Bellerbys College Oxford, Trajan House, Mill Street, Oxford, OX2 0DJ, UK
e-mail: emma525989@hotmail.com

A. Cacchione
Department of Social Science & Linguistic Centre, University of Molise, Campobasso, Italy
e-mail: annamaria.cacchione@unimol.it

S. A. Petersen
SINTEF Technology and Society S.P. Andersens vei 5, Lerkendal, 7465 Trondheim, Norway
e-mail: sobah.petersen@sintef.no

M. Winter
602 Watts Building, University of Brighton, Brighton, BN2 4GJ, UK
e-mail: marcus.winter@brighton.ac.uk

D. G. Sampson et al. (eds.), *Digital Systems for Open Access to Formal and Informal Learning*,
DOI 10.1007/978-3-319-02264-2_9,

ideas from social network analysis and other disciplines to the area of technology-enhanced learning. This brings new insights and new means of understanding learning and the behaviour of individual learners as well as communities of learners, or more appropriately, networks or crowds of learners (Altshuler et al. 2012).

In this chapter, we present some user studies that were conducted in several different countries, where the learners were provided with a mobile language-learning app, LingoBee, to support their learning process. LingoBee is based on ideas that have been explored in an earlier project using a mobile app called Cloudbank (Pemberton et al. 2010), which has a wiki-like functionality to crowdsource language content from anonymous users. User studies conducted during the JISC-funded Cloudbank project showed that users were also social networkers. The project demonstrated that experience of applications such as Facebook played an important role in learners' expectation; e.g. some users expressed their desire to have a public identity and wanted functionalities that would support multiple contributions, comments and a ratings system to "bubble up" good content (Pemberton and Winter 2011). This experience highlights the role that social media plays in our lives and our learning processes and how users' expectations are being affected by it. The design of "LingoBee also supports learner communities through user profiles, user groups, content ratings and other social networking functionality that help to make language learning more collaborative and help to overcome isolation in a foreign country" (Situated Mobile Language Learning, SIMOLA 2012b).

Our work is directly connected to the issue of open access to formal and informal learning, as it investigates the use of a mobile language-learning app that is freely available to download and has been designed to support remote/isolated learners. The expansion of mobile Internet access, alongside the expanding availability of mobile content, applications and services is currently transforming the lives of millions of people across the globe. Mobile devices have already become the primary means of accessing the Internet for many and will become the primary platform for access to information content and services which will empower new socio-economic groups through transforming access to health care, education and government/financial services (IFLA 2013, p. 26). Mobile and learning are so closely connected that experts have started to define learning as "native" in the mobile world:

> Learning is going "native" in the mobile world—ubiquitous, always on, real-time, built into everyday life. The kinds of learning that have traditionally been the subject of classroom instruction will soon cease to necessarily be an event-driven static interruption for employees, students, and customers (Brandon 2013).

Technology is thus refining the "natural alliance between learning as a contextual activity and the new personal, mobile technology, so that it is becoming feasible to equip learners with powerful tools to support learning anytime, anywhere" (Sharples et al. 2002, p. 220).

The key feature of what Sharples defines as "natural alliance" is contextuality, that is, the possibility to interact with and within personal physical reality and with and within other people's physical realities. That is also what enables the development and the success of social media: It is not by chance that social media is increasingly becoming the natural place where learning happens and, on the contrary, the majority of learning platforms are structured as social networks. That is also the case of our mobile app, LingoBee, and of its users, acting as social networkers. It thus appears to be an ideal environment for informal learning that could also support formal learning, as it actually happened. Its user friendliness, the basic social media functionalities and the high affordability of the app—freely downloadable for Android-based devices—are all factors for an effective promotion of access to learning.

The aim of this chapter is to identify whether LingoBee users act as a true social network or some kind of hybrid and to identify and describe the types of LingoBee users and the implications this has on how best to support teaching and learning, to positively impact on learners' engagement and use of LingoBee.

The rest of this chapter is organized as follows: Sect. 2 provides a literature review; Sect. 3 provides an outline of the functionality of LingoBee; Sect. 4 outlines the general study design for the user studies; Sect. 5 describes the data collection methods and the types of social networkers that are relevant for LingoBee; Sect. 6 presents evidence of users as social networkers; Sect. 7 presents and discusses implications for learning; and Sect. 8 summarises the chapter.

2 Literature Review

2.1 Mobile Learning, Social Media and Open Access

In a recent report from The MotiF project on mobile learning, they defined mobile learning as "Leveraging ubiquitous mobile technology for the adoption or augmentation of knowledge, behaviors, or skills through education, training, or performance support while the mobility of the learner may be independent of time, location, and space" (Advanced Distributed Learning (ADL) Initiative 2013, p. 5). It was also noted that although smartphones and tablets have been around for a while, often educators and designers creating learning apps are "failing to leverage the unique capabilities of the mobile platform" such as utilising the built-in camera, GPS, etc. (Advanced Distributed Learning (ADL) Initiative 2013, p. 7).

"M-learners can enjoy a high degree of *collaboration* by making rich connections to other people and resources mediated by a mobile device. This often-reported high level of networking creates shared, socially interactive environments so m-learners can readily communicate multi-modally with peers, teachers and other experts, and exchange information. Learners consume, produce and exchange an array of 'content', sharing information and artefacts across time and place" (Kearney et al. 2012, p. 10). This clearly identifies that mobile learning has the potential to support open access to education, with potential learners using their smartphones and the support of a community to continue lifelong learning in both informal and formal ways.

Mobile learning clearly has the potential to open up access to learning. "Unlike other learning technologies, mobile learning is unique in that it can accommodate both formal and informal learning in collaborative or individual learning modes" (Advanced Distributed Learning (ADL) Initiative 2013, p. 5). Mobile learning emphasizes the active involvement of the learner where formal learning is complemented by informal learning. This is well in line with the constructivist thinking, in particular, social constructivism (Vygotsky 1978) that focuses on the social context that shapes the construction of knowledge, which is important in language learning. Learning languages is strongly influenced by situations (Ogata and Yoneo 2004), and language and culture are inextricably linked (Tang 1999). This fits well within the concept of situated learning proposed by Lave and Wenger (Lave and Wenger 1991). Interacting with the environment surrounding a language learner is important in acquiring and practicing a language and thus language learners' social networks can play an important role in their language-learning processes. "Social media offer novel possibilities in order to expand and diversify the learning opportunities…and has growing relevance and importance for everyday and lifelong learning practices" (Cobo 2013).

The rapid acceptance of social media in peoples' lives, especially among "digital natives", opens the potential to leverage it as a means to support lifelong learning within informal settings. Many interactions on social networking sites have the potential to be learning moments for all who see them, e.g. a shared article, an image or a geotag all have the potential to result in learning.

However, levels of participation and learner engagement are issues that not only surround the arena of formal open access to learning in the form of MOOCs and their low completion rates but are also the features of any online network, formal or otherwise. As Neilsen identifies when talking about the 90–9-1 rule of online participation, "All large-scale, multi-user communities and online social networks that rely on users to contribute content…share one property: *most users don't participate* very much. Often, they simply *lurk* in the background" (Nielsen 2006). Lurking and other social networking behaviour needs to be identified and understood within the context of informal and mobile learning to open up access to learning and to promote the use of such tools to encourage lifelong learning.

3 LingoBee Mobile App

LingoBee is a mobile app to support situated mobile language learning and to help the learners in linguistic and cultural diversity. Based on the ideas of situated learning (Lave and Wenger 1991) and contextualized learning, e.g. Luckin (2010), it is designed to capture language elements that learners come across in their everyday lives, whenever and wherever. Ideas of crowdsourcing and social networking are used to collect, share and annotate the contributions of all learners in a shared online repository as shown in Fig. 9.1a. Users are able to add entries, which may be words or phrases, to the LingoBee repository, which can be accessed by other users of LingoBee; see Fig. 9.1b which shows a definition containing a picture and Fig. 9.1c where the user can enter new definitions. Learners are also able to add

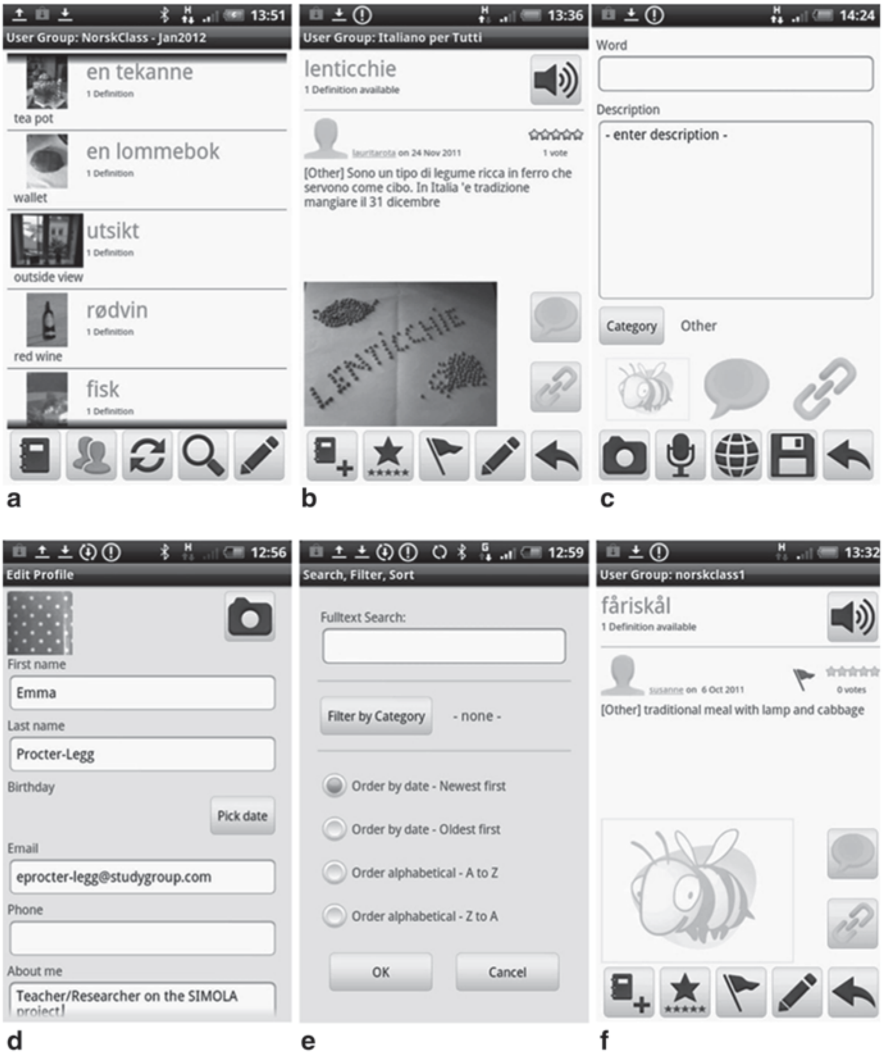


Fig. 9.1 LingoBee functionality. **a** LingoBee repository. **b** Definition of an entry. **c** Editor to enter a definition. **d** User profile. **e** Browsing: search, filter, sort. **f** A flagged definition

new definitions to existing entries and rate existing definitions; e.g. in Fig. 9.1b the entry "lenticchie" has one definition and users have rated it as five stars. Each entry can contain multimedia elements such as a picture and/or audio content as well as web links. In addition, a text-to-speech functionality is available for the correct pronunciation of the entries. Language articles are co-constructed through the use of LingoBee, where students add items and build meaning together through dialogue created via multiple entries.

To support social networking, LingoBee provides the capability for the users to define their profiles including a username and contact details as shown in Fig. 9.1d. Users are able to view or browse through the contents of the LingoBee repository and the functionalities to support browsing are shown in Fig. 9.1e. Other ideas from social networks have been included such as peer rating as shown in Fig. 9.1b and flagging an entry as a form of feedback as shown in Fig. 9.1f.

LingoBee was developed as part of an EU LLP project SIMOLA, with partners from six different countries (SIMOLA 2012b). Thus, LingoBee is supported in six different European languages and Japanese. It is a free open-source mobile app developed for the Android platform.

4 User Studies

User studies of LingoBee have been conducted in several locations (Italy, UK, Norway, Lithuania, Hungary and Japan) since July 2011. The user studies presented in this chapter were carried out in three different European educational establishments: Bellerbys College, Oxford, part of Study Group UK (Study Group), The University of Molise (Unimol), Italy, and the Department of Social Science and Linguistic Centre and Department of Languages and Communication at the Norwegian University of Science and Technology (NTNU). The users were all language learners, enrolled on university or preuniversity courses.

The study design involved introducing LingoBee to international students learning English, Italian and Norwegian, and providing them with a free smartphone for use in their daily lives. LingoBee was formally introduced to the students in a classroom setting, although it did not always form any part of the classroom activities. In general, the students were provided smartphones with the LingoBee app pre-installed. LingoBee was introduced in different ways: by presenting the basic functionalities for adding content to LingoBee, through demonstrating the functionality through a video, through the help guides uploaded onto a virtual learning environment (VLE) and through activities designed to encourage students to explore the functions of the app.

Considering the users as motivated, independent learners, which is one of the findings of the studies conducted by (Pemberton and Winter 2011), one of the aims when introducing LingoBee was to show the students the basic functionality without influencing them with our views of the app and its usage. Another of the aims of evaluation was to see how the users perceived the system and used the functionality.

5 Method

The results presented in this chapter are based on the content in the LingoBee repository and the pre- and post-intervention questionnaires and interviews conducted with the participants in the studies at Study Group, Unimol and NTNU. In addition to these, data logs created by the LingoBee system were used to determine some of the activities of the users that were not directly visible from the LingoBee mobile app interface. Google Analytics were also used to detect the activities of all LingoBee users and analysed to support the results from the user studies in identifying different types of user behaviour. Our main focus so far has been on the content created by the users in the repository.

In this chapter, the main analysis has been to identify LingoBee users as social networkers. Based on the motivations for the design of LingoBee to incorporate features associated with social networks and the observation of behaviours of the users involved in the trials, we concluded that there were a number of different types of LingoBee users. We considered a number of different classifications of online roles and social networking types, such as "Lurkers", "Newbies", "Celebrities", "Conversationalists", etc., identified by Golder (2003), Haythornwaite and Hagar (2005) and Fisher et al. (2006), as well as roles identified in Wikipedia, such as "Substantive Experts" and "Social Networkers" (Welser et al. 2011), before deciding upon using the types of social networking users identified in The Social Technographic Ladder by Forrester Research Inc. ("The Social Technographics Ladder" 2011–2012) as a basis for our analysis. We identified the following types of users and their associated behaviours as relevant for LingoBee and potentially other social networking-based language-learning apps:

- Creators: users who create entries in the LingoBee repository by adding new words, phrases, additional definitions and multimedia content
- Conversationalists: users who add entries onto other users' definitions
- Critics: users who provide peer reviews by using the rating and flagging functionality on the content in the LingoBee repository
- Collectors: users who add other users' definitions from the LingoBee repository to their favourites list. In LingoBee, an individual user's word list or favourites are stored on their mobile device so they can access them anytime. The favourites list automatically includes any entries created by the user, plus entries they have chosen to download from the repository to store on their phone
- Spectators: users who viewed the content in the LingoBee repository
- Inactives: users who were none of the above or users who were active users at the beginning and then stopped

6 Lingobee Users as Social Networkers

Based on the observations and results of the studies at Study Group, Unimol and NTNU, we can categorise LingoBee users as social networkers, using the categories described in Sect. 5. We will illustrate the different types of users, using examples sourced from the LingoBee repository, the post-intervention questionnaires and the interviews from the three user studies as well as data collected by Google Analytics on the wider use of LingoBee. The Google Analytics data include data about all

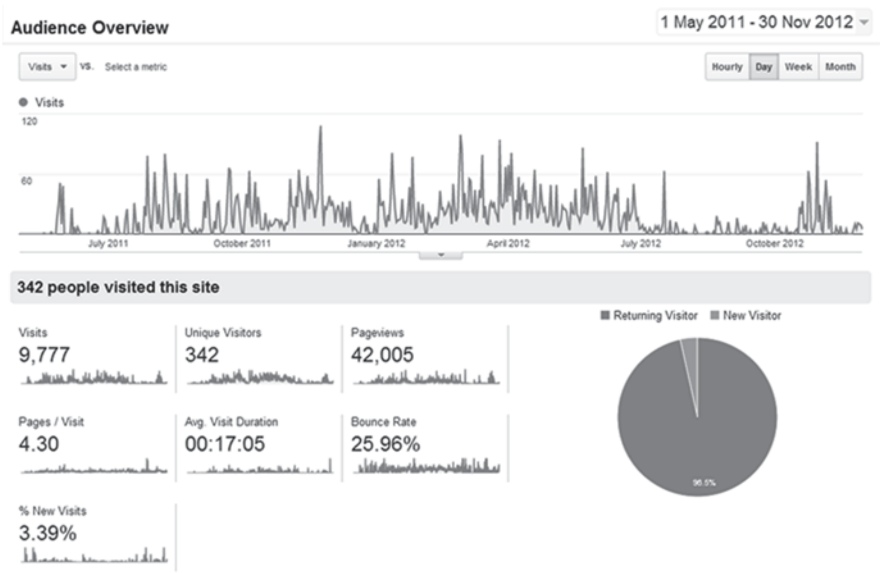


Fig. 9.2 An overview of all LingoBee users

users of LingoBee collected between 1 May 2011 and 30 November 2012 (the user trials ran between June 2011 and July 2012). The data include usage figures for any user who downloaded, installed and opened the LingoBee app irrespective of whether they were a participant in the trials. A summary of the overall usage figures and average page views per visit is shown in Fig. 9.2 which shows that there were 342 unique users, which is far above the number of learners involved in the trials. It should be noted that there are limitations to the data collected via Google Analytics as they are not always precise; however, they do give a good overview and a clear indication of the level of usage of LingoBee by all users.

The most obvious category of users is the Creator as evidenced by the LingoBee repository, which is accessible from SIMOLA (2012a) and examples of which are presented in Fig. 9.1a, b and f). The Creator category is also backed by the Google Analytics data presented in Table 9.1, which show that 12.5 % of all page views in the app were for the "Add Definition" page. It is interesting to note that from our observations, Creators consisted of two main types: (1) true Creators who created entries autonomously and adopted LingoBee as a natural part of their language learning, adding an entry when they saw something new, and (2) those who required prompting to add new content. The analysis of our results concluded that the initial studies at all three locations experienced the second type of Creators. Thus, prompts were used to stimulate the creation of more content, such as tasks set by the teacher, e.g. scavenger hunts or a Facebook group to support each other.

In the same way, there appears to be two types of Conversationalists: (1) true Conversationalists who interact and exchange content taking into consideration

Table 9.1 Top ten functions in LingoBee according to the number of page views

LingoBee functionality (pages)	Percentage of total page views (total page views 42,005)
Browse favourites	22.09 %
View definitions	21.40 %
View word	14.69 %
Add definition	12.53 %
Add picture	8.16 %
Edit definition	3.17 %
Search and filter	2.45 %
Join user group	2.35 %
Add hyperlink	2.04 %
User group	1.85 %

what others previously said, just like in any other real-life conversation, and (2) those who simply add entries in a row, without being influenced by others' content. The example in Fig. 9.3 (Petersen et al. 2013) shows a "conversation" where users have created collective definitions in a wiki-style. Such users are Conversationalists, where one user's definition of an entry is complemented by another user's definition. In this particular example, a conversation between the teacher and a student is shown. This is also a prime example of how a conversation between a learner and a native speaker could take place through LingoBee, where LingoBee users include native speakers as well as learners. The conversations through LingoBee are most often asynchronous, as the app does not currently alert the user that another entry has been added to their definition, which allows users time to consider and construct their response. There are several other examples where one user's entries have additional definitions. For example, in the Unimol user group, the following entries were made:

Three different entries for SEDIA (chair):

04/04/2012,B, sedia,
22/04/2012,F, sedia,
03/04/2012,Si, Se, sedia
Four different entries for POLLO (chicken):
19/11/2011,E, pollo al curry,
29/11/2011,P, Pollo,
01/12/2011,P, Pollo,
19/04/2012,S, Pollo,

These are not true conversations; they are multiple attempts at one single definition by different users in the Unimol trials. It is interesting to see such examples. Here, the users are in fact Creators of new entries. However, it appears that they are unaware of existing entries, thus creating a new entry rather than adding to the existing definitions, i.e. a conversation. Had the entry "Pollo" existed before the user wished to add the entry "pollo al curry", would it have been a conversation? These are the types of questions that we focused on answering through our analysis

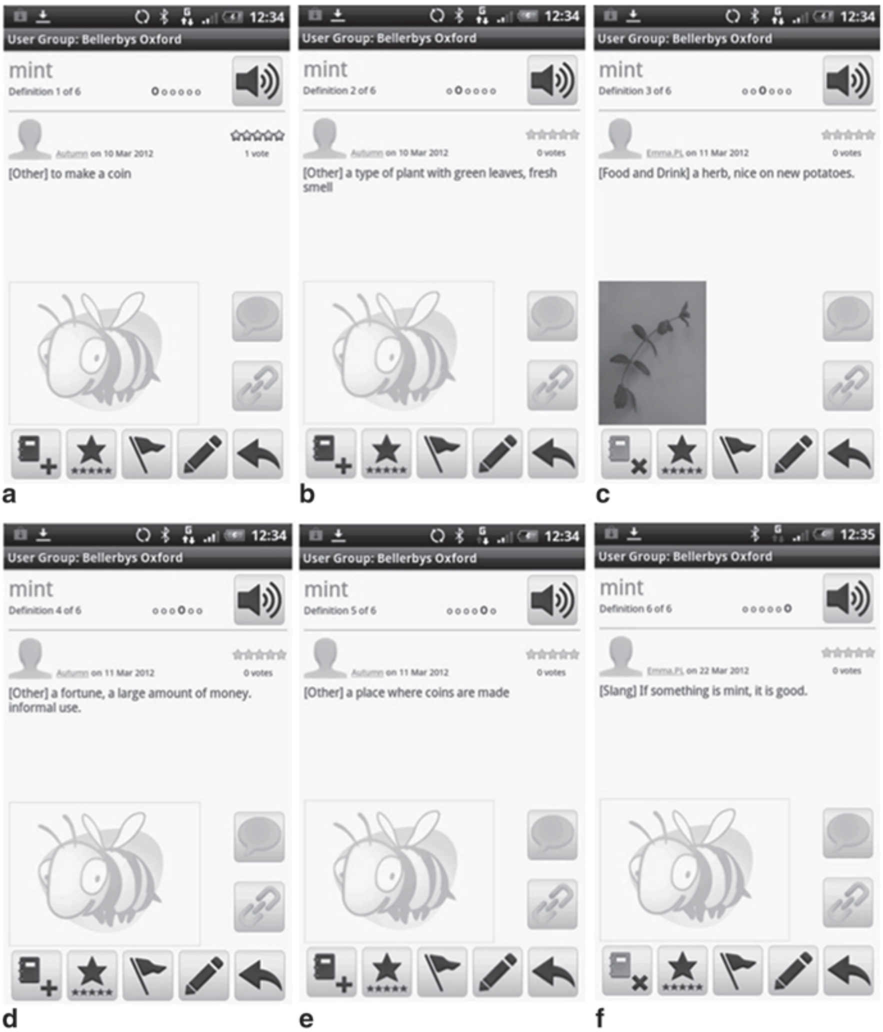
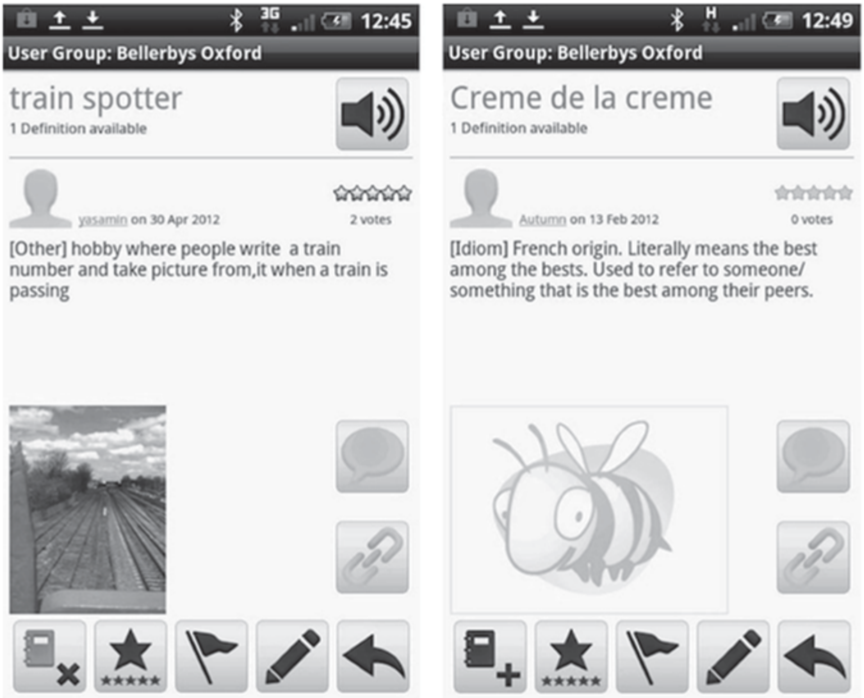


Fig. 9.3 Definitions of “mint”: a conversation between a learner and the teacher. (© 2013 by IGI Global. Reprinted by permission of the publisher)

and interviews. With regard to this point, we can observe that these “conversations” are due to a feature of LingoBee, as it automatically detects identical word/phrases entered into a user group and links them together, but it does not currently inform the user that there is already an entry in the repository for that word or term. If it did warn the user, they may be less inclined to make a separate entry.

Examples of Critics can be seen in Figs. 9.1, 9.3 and 9.4; users have rated entries in the LingoBee repository, e.g. in Figs. 9.1b and 9.2, the entries have a rating of five stars. Similarly, users have flagged content; e.g. in Fig. 9.1f, the entry is flagged as it is spelt incorrectly. Flagging could indicate several things such as an incorrect



a b

User	Word	Description	Image	Audio	Link	Rating	Favourites	Flag
yasamin	train spotter	hobby where p	http://itrg.brighton			5	6	
Autumn	Creme de la cr	French origin. Literally means the				0	3	

c

Fig. 9.4 **a** Definitions of train spotter. **b** Definition of crème de la crème. **c** Extracts from the logs showing number of times these entries have been added to a user's favourites list

spelling, an inappropriate entry, abusive content or spam. When a user flags an entry, they can indicate the reason for flagging the entry with a simple check box system that then notifies the LingoBee administrator of the user group. Both learners and teachers acted as Critics; e.g. the entry in Fig. 9.1f was flagged by the teacher to draw the learners' attention to the incorrect spelling of the entry.

Collectors are not obvious from the LingoBee interface. However, we asked in the post-intervention questionnaire "Is it helpful to see the words and phrases added to LingoBee by other users?" rated on a Likert scale of 1–7, where 7 indicates the highest and 1 indicates the lowest level of agreement. The combined results, across all three studies, showed that 68 % of all respondents agreed and that 42 % strongly agreed (rated 7) with this statement. This, combined with the Google Analytics logs created by the system, makes it is possible to identify entries from the repository that have been added to other users' favourites lists. Examples of Collectors are

Table 9.2 Frequency and recency of LingoBee app visits

Number of days since last visit to LingoBee (app use)	Visits (total visits 9,777)	Page views (total page views 42,005)
0	7,469	31,765
1	751	3,142
2	379	1,587
3	233	929
4	153	791
5	110	410
6	93	473
7	66	296
8–14	252	1,302
15–30	158	770
31–60	63	348
61–120	27	69
121–364	10	52
365+	13	71

shown in Fig. 9.4; both the entries have only one definition, but you can see from Fig. 9.4c, from the data collected by LingoBee, that they have been added to favourites six and three times, respectively, although we cannot identify, from the data collected, which users added those entries to their favourites list. However, we can see from Table 9.1 that the most frequently visited page in the app is the Favourites page with 22 % of all views, which may support the idea that LingoBee users collect and view their favourite content from the repository.

It is not possible to detect Spectators from the LingoBee interface. However, based on the data from the Google Analytics, the post-intervention questionnaires and interviews, it is clear that all three studies had users who were Spectators that browsed the LingoBee repository. The Google Analytics data collected from all the LingoBee users are shown in Tables 9.1 and 9.2 and these data also support the existence of Spectators. The post-intervention questionnaire included questions such as the number of hours a learner used LingoBee during the day and the level of LingoBee usage in different locations such as home, city, etc. on a Likert scale of 1–7. The data from the questionnaires show that some students reported a higher number of hours of using LingoBee per day compared to the level of activity shown on the logs in terms of them as Creators, Conversationalists, Critics and Collectors. These, combined with the data in Tables 9.1 and 9.2, indicate that some users were Spectators. Table 9.2 shows the frequency of usage of LingoBee, with most of the page visits being repeat visits on the same day, which is an indication of the level of usage/addictiveness of the app. In addition to this, some of the learners who were interviewed reported face-to-face discussions related to LingoBee content with other LingoBee users in their language classes.

Some users were Inactives as they joined the study and accepted a smartphone with LingoBee pre-installed, but either never used LingoBee or stopped using it during the course of the user study when they returned the smartphone and stopped attending the language classes for various reasons.

In addition to the types of users discussed so far, the response to the post-intervention question "What additional functionalities would you like in LingoBee to support language learning?" provided a few interesting responses such as "(a) *widget that shows best definition/information ranked, so people can compete (against) each other, to be ranked on the table….*", "*It could be more interactive like a network. Maybe using questions about the name of some objects and doing a competition between the users with a game*" and "*motivation*". These responses from learners using LingoBee illuminate two key points, the first that students like the idea of using LingoBee in a similar way to which they use other social media, e.g. number of likes on Facebook or Instagram or playing competitive games via Facebook, and they could possibly be motivated by this. If students tend to think it could be more "like a network", maybe LingoBee is not a real social network, at least not in the sense they would like. It currently has basic social networking functionalities, but it could allow more interaction and be more integrated with other networks—e.g. allowing automatic integration with Facebook and Twitter. Furthermore, within the growing family of social media, LingoBee appears to resemble interest-focused networks like Instagram or Pinterest, where you do not necessarily just search for friends but for people sharing the same interests as you.

The second point is that a competitive spirit is indicated as a means of motivation and recognition among peers and supports the growing movement towards the gamification of learning. This identifies additional types of social networkers among language learners: Competitors and Motivators.

7 Implications for Learning

In this section, we analyse the types of LingoBee users from the perspectives of the work produced in the area of technology-enhanced learning, in particular, learning contexts. An interesting approach is developed by Luckin, whose ideas are based on the zone of proximal development proposed by Vygotsky (1978). Luckin added two additional concepts by defining a zone of proximal adjustment and a zone of available assistance (Luckin 2009). The zone of available assistance describes a variety of assistance that can be made available to a learner, while the zone of proximal adjustment represents a selection from the zone of available assistance for a given learner and the educational situation.

LingoBee users as social networkers or as a community of learners can be considered in the context of the ideas proposed by Luckin, as shown in Fig. 9.5. The tools available to users within the zone of available assistance are: other LingoBee users, native speakers, the teacher as well as a myriad of tools and technologies, such as online dictionaries providing potential assistance to the learners. The key to engaging learners in the user studies was by ensuring that LingoBee and other LingoBee users moved from the zone of available assistance into the zone of proximal adjustment. The first trial group at Study Group struggled to have any tools in their zone of proximal adjustment, they had never used mobile phones in a formal

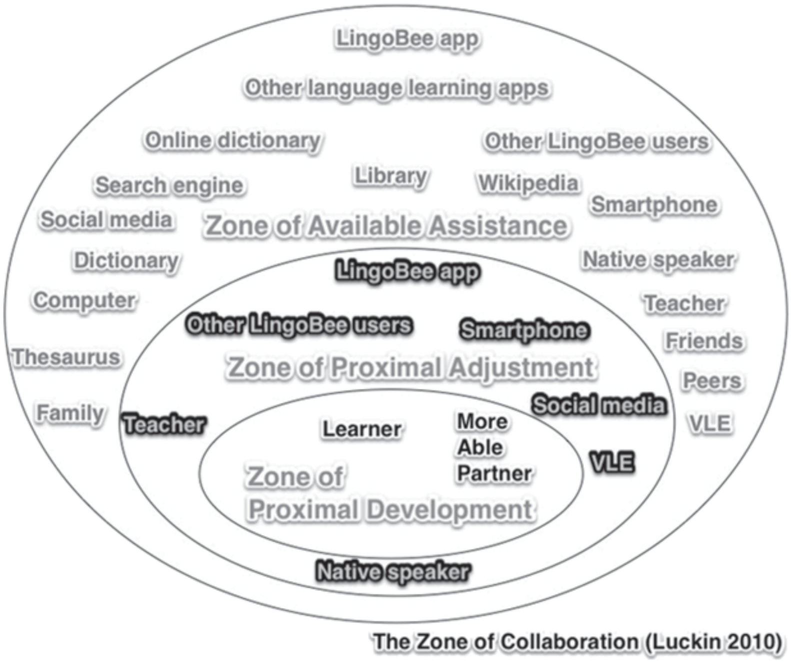


Fig. 9.5 The zone of collaboration around LingoBee users. (Adapted from Luckin 2010)

learning environment, they were not able to use the VLE which contained information to support their use of LingoBee and they were too new to the college to understand the importance of being able to use these. Their main tools or available assistance was their teacher, email and text messages, and the LingoBee app (only when supported to use it). In the second Study Group user study, through class discussions, it became apparent that the entries by one particular user was liked by the other participants of the study and stimulated them to learn the language and use LingoBee; thus, this user became a More Able Partner (Luckin 2010) or at least another tool in their zone of proximal adjustment. This example of a learner as the More Able Other or More Knowledgeable Other is discussed in greater detail in Adlard et al. (2012). Similarly, some of the entries by users in the NTNU user study were rated by the teacher, encouraging and promoting those users and similar entries in the LingoBee repository. The example in Fig. 9.3 shows how the teacher can provide support to a learner by engaging in a conversation with the learner through LingoBee. What is important is that the network of learners and through ideas of social networking, LingoBee users could provide implicit support to one another in their learning process. Thus, the other LingoBee users within a user group can play a significant role in both the zone of proximal adjustment and the zone of proximal development by acting as a More Able Partner.

The Luckin diagram works as a powerful tool for teachers and researchers. It helps to assess the preliminary situation in order to prepare the setting to introduce the app. It also highlights the constraints that could have a negative impact on the learning process. In any case, the experiences of our studies show that current users' expectations of social networking cannot be ignored as they are part of their mind-set and orientate them in creating, selecting and sharing learning objects. The sharing of learning objects by a user in the Study Group trial, where the sharing extended beyond LingoBee into other social networks, is discussed in detail in Procter-Legg et al. (2013).

To enable LingoBee users to provide relevant support to one another, there is a need "to have a big group (using LingoBee)", as stated by one of the users in their post-intervention questionnaire. Our earlier user studies indicated that the learners required assistance in starting to use LingoBee, thus requiring scaffolding initially by the teacher in various ways. For example, in addition to the teacher being a Conversationalist to prompt the users, Study Group introduced various activities to support learning, e.g. a scavenger hunt, walking tour, show and tell activities (often around food), access to a VLE LingoBee course and tasks to engage with the target culture such as watching specific television programmes. Similarly, the second study conducted at Unimol introduced a Facebook support group to motivate and encourage the users. Our studies suggest there is a need for scaffolding when using LingoBee and when engaging users with the other tools in their zone of proximal assistance (Wood et al. 1976; Vygotsky 1978; Luckin 2010).

One of the intentions of the SIMOLA project, which created LingoBee, was to create cloud-based communities of learners that support remote learners to learn a language informally via their smartphones. App-based learning, built around the ideas of social media and social networking, clearly has the potential to support open access to informal learners and to provide them with an active learning community. LingoBee has shown that it has the potential to offer adaptive and personalised learning, allowing users to search for and share language-related and cultural-related content that is of interest to them. Users expressed during and after the trials that they liked that they could learn language from each other and that although they may not always have been interested in all of the content being produced by each user, they are able to seek out entries that are of interest to them. This is illustrated in Fig. 9.3, Mint, where the learner was interested in and responded to and interacted with the teacher/researcher in a time and place that suited the learner.

As Cobo reflects on her blog "…social media offer novel possibilities in order to expand and diversify the learning opportunities". She also indicates that further research will be needed to see how the benefits of social media and the open access will be "embedded into formal and non-formal learning practices" (Cobo 2013). LingoBee is an open access repository as any entries created are visible via the LingoBee repository available through the app and a website (SIMOLA 2012a), and has created a network of language learners sharing their learning in an open way.

With open access to learning via apps such as LingoBee, one way to encourage more participation, according to Neilsen is to "make it easy to contribute" (Neilsen 2006).

8 Summary

This chapter presents LingoBee users as social networkers and describes and discusses the types of users that can be identified by analysing the content created in the LingoBee repository and the Google Analytics data that are available. Borrowing ideas from other studies conducted on social network users, we can identify that LingoBee language learners use LingoBee as a social network. As social networkers, they are: Creators of content; Conversationalists, Critics of other users' entries; Collectors who download entries created by other users; as Spectators who browse the content as well as Inactives. In addition to this, from the post-intervention questionnaires and interviews, it can be seen that the language learners are stimulated by the contributions of other users and welcome competition. LingoBee users as social networkers were analysed and discussed based on Luckin's idea of the zone of proximal assistance and the zone of available assistance.

The next stage of our work is to further analyse the data for a better understanding of language learners as social networkers and whether the level of learning is directly or indirectly influenced by the type of social networking behaviour the learner participates in.

Acknowledgments This work has been conducted within the European Union's Lifelong Learning Programme, SIMOLA, Project number LLP 511776-LLP-1–2010-1-UK-KA3-KA3. We would also like to thank all the language teachers involved with the user studies for providing access to their students.

References

Adlard, R., Ottway, T., & Procter-Legg, E. (2012). Crowdsourcing with the LingoBee app: A study in facilitating pollination across language and culture in self-directed learning. *International Journal of Computer-Assisted Language Learning and Teaching (IJCALLT), 2*(4), 17–33.

Advanced Distributed Learning (ADL) Initiative. (2013). The MoTIF project: Mobile learning Survey report. [Report].

Altshuler, Y., Fire, M., Aharony, N., Elovici, Y., & Pentland, A. (2012). *How many makes a crowd? On the evolution of learning as a factor of community coverage*. Paper presented at the International Conference on Social Computing, Behavioural and Cultural Modelling, and Prediction.

Brandon, B. (2013). Mobile disruption and mLearnCon 2013, learning solution magazine. http://www.learningsolutionsmag.com/articles/1178/mobile-disruption-and-mlearncon-2013. Accessed 28 Sept 2013.

Cobo, C. (2013). Social media a tool for connecting formal and informal learning. http://blogs.oii.ox.ac.uk/cobo/?p=675. Accessed 14th Sept 2013.

Fisher, D., Smith, M., & Welser, H. T. (2006). *You are who you talk to: Detecting roles in usenet groups*. In Proceedings of the 39th Hawaii International Conference on Systems Sciences (HICSS).

Golder, S. (2003). *A typology of social roles in usenet*. Undergraduate thesis, Harvard University.

Haythornthwaite, C., & Hagar, C. (2005). The social world of the web. *Annual Review of Information Science and Technology, 39,* 311–346.

Haythornwaite, C. (2011). *Learning networks, crowds and communities*. Paper presented at the Learning and Analytics Conference LAK'11, Banff, Canada.

IFLA. (International Federation of Library Associations) Trend Report. (2013). Literature review. http://trends.ifla.org/files/trends/assets/literature-review_2013-02-22.pdf. Accessed 14th Sept 2013.
Jarvis, J. (2011). *Public parts: How sharing in the digital age improves the way we work and live*. New York: Simon & Schuster.
Kearney, M., Schuck, S., Burden, K., & Aubusson, P. (2012). Viewing mobile learning from a pedagogical perspective. *Research in Learning Technology, 20,* 1–17. doi:10.3402/rlt.v20i0/14406.
Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. New York: Cambridge University Press.
Luckin, R. (2009). *Learning, context and the role of technology*. London: Institute of Education, University of London.
Luckin, R. (2010). *Re-designing learning contexts*. London: Routledge Taylor & Francis Group.
Nielsen, J. (2006). Participation inequality: Encouraging more users to contribute. http://www.nngroup.com/articles/participation-inequality. Accessed 14th Sept 2013.
Ogata, H., & Yoneo, Y. (2004, March 23–25). *Knowledge awareness map for computer-supported ubiquitous language-learning*. Paper presented at the International Workshop on Wireless and Mobile Technologies in Education, WMTE2004, Taiwan.
Pemberton, L., & Winter, M. (2011). *Learning from formative evaluation in use: A case study of a mobile application for language learners*. Paper presented at the MLearn 2011, Beijing, China.
Pemberton, L., Winter, M., & Fallahkair, S. (2010). Collaborative mobile knowledge sharing for language learners. *Journal of the Research Centre for Educational Technology, 6*(1), 144–148.
Petersen, S. A., Procter-Legg, E., & Cacchione, A. (2013). Creativity and mobile language learning using LingoBee. *International Journal of Mobile and Blended Learning, 5*(3), 34–51.
Procter-Legg, E., Petersen, S., & Cacchione, A. (2013). *LingoBee—creating a buzz in mobile language learning. Synergic integration of formal and informal e-learning environments for adult lifelong learners* (pp. 199–221). Hershey: IGI Global.
Sharples, M., Corlett, D., & Westmancott, O. (2002). The design and implementation of a mobile learning resource. *Personal and Ubiquitous Computing, 6*(3), 220–234.
SIMOLA. (2012a). LingoBee repository. http://itrg.brighton.ac.uk/simola.org/lingobee/index.php. Accessed 1st June 2012.
SIMOLA. (2012b). Situated mobile language learning. http://itrg.brighton.ac.uk/simola.org. Accessed 1st June 2012.
Tang, R. (1999). The place of "culture" in the foreign language classroom: A reflection. *The Internet TESL Journal, 5*(8), 1–2. http://iteslj.org/Articles/Tang-Culture.html.
The Social Technographics Ladder. (2011–2012). http://empowered.forrester.com/ladder2010. Accessed 1st June 2012.
Vygotsky, L. S. (1978). *Mind in society. The development of higher psychological processes*. USA: Harvard University Press.
Welser, H. T., Cosley, D., Kossinets, G., Lin, A., Dokshin, F., Gay, G., & Smith, M. (2011). *Finding social roles in Wikipedia*. Paper presented at Conference'11, Seattle, February. New York: ACM, pp. 122–129.
Wood, D. J., Bruner, J. S., & Ross, G. (1976). The role of tutoring in problem solving. *Journal of Child Psychiatry and Psychology, 17*(2), 89–100.

Chapter 10
A Mobile Location-Based Situated Learning Framework for Supporting Critical Thinking: A Requirements Analysis Study

Abeer Alnuaim, Praminda Caleb-Solly and Christine Perry

1 Introduction

The strength of mobile learning lies in taking advantage of the rapidly evolving scope of mobile technologies. Woodill (2011) acknowledges that there is a shift in the perception of mobile learning, claiming that "Ten years ago, mobile learning was about displaying e-learning on a small screen". He argues that now it allows learners to learn in an "anywhere, anytime" manner and to access information when needed. Being able to sense the context and location of the learner has opened up many possibilities for researchers to create more engaging, contextualised, and personalised learning activities, thus maximising the benefit of the learning experience. Personalisation is one of the strengths of mobile learning. According to Kinshuk et al. (2009), personalisation could be acquired either by adapting to the learner's characteristics, learning styles, performance, and needs, or by adapting to the context in which the learning is taking place.

This chapter presents the requirements work carried out as part of developing an intervention to improve students' analysis and critical thinking skills using location-based mobile learning. The idea for the research emerged from seeking to identify ways of getting students studying human–computer interaction (HCI) into real-world environments, similar to those in which they will eventually be designing, in order to enhance their ability to identify opportunities for innovative design.

A. Alnuaim (✉) · P. Caleb-Solly · C. Perry
Department of Computer Science and Creative Technologies,
University of the West of England, Frenchay Campus, Bristol BS16 1QY, UK
e-mail: abeer.alnuaim@uwe.ac.uk

King Saud University, Riyadh, Saudi Arabia

P. Caleb-Solly
e-mail: praminda.caleb-solly@uwe.ac.uk

C. Perry
e-mail: Christine.Perry@uwe.ac.uk

D. G. Sampson et al. (eds.), *Digital Systems for Open Access to Formal and Informal Learning*,
DOI 10.1007/978-3-319-02264-2_10,

Sending students out into such environments with a brief to be evaluative and analytical, without the presence of a teacher, can lead to a superficial and frustrating experience, especially for students with beginning levels of analysis and limited critical thinking skills. It is not always possible for teachers to accompany students, and more positively, prompts to provoke the development of their own thinking might be more beneficial than immediate input from teachers who are present.

In order to design the system, the first stage is to conduct a comprehensive requirements study to understand specific student and staff needs in the envisaged scenario. As part of this study, we were interested in identifying weaknesses in the current mode of teaching and problems experienced by students in understanding key concepts. This information is crucial in determining the type and nature of location-based hints and formative feedback that the system can provide to aid students' understanding of the context they are in. It is important to ensure that students do not miss key areas that may help them with analysing the situation properly. The hints can also give them the start of threads leading to the development of innovative ideas, thus providing added value to their development as designers facilitated through the mobile-based learning system. The fact that the structured support would be available to all students to use at their own pace and convenience ensures equitable access to learning.

The next section of the chapter explains context-aware and location-based learning, and the relevance of situated learning and critical thinking to this study, summarising the relevant literature in the area. This is followed by an outline of the research methodology adopted in the study, detailing the requirements gathering process and insights gained and explaining how these have been incorporated into the initial prototype designs of the application.

2 Literature Review

2.1 Context-Aware and Location-Based Mobile Learning

Context-aware computing is a rapidly growing research area. It aims to promote a flowing interaction between humans and technology (Barkhuus and Dey 2003), collecting information from the surroundings of the user to provide an understanding of what is currently happening (Naismith et al. 2004).

Abowd et al. (1999) define a context-aware system as follows: "A system is context-aware if it uses context to provide relevant information and/or services to the user, where relevancy depends on the user's task". Context, according to Brown et al. (2010), is "the formal or informal setting in which a situation occurs; it can include many aspects or dimensions, such as location, time (year/month/day), personal and social activity, resources, and goals and task structures of groups and individuals".

Barkhuus and Dey (2003) define three levels of context-aware applications depending on the interactivity with the user:

1. Personalisation: The user determines the way the application behaves in a particular situation.
2. Active context-aware: The application changes the content independently, based on the sensor data.
3. Passive context-aware: The application presents the changed context sensor data to the user and lets him/her take control of decisions about how the application behaves.

Much research has shown the significance of context-awareness in education (Yau and Joy 2009; Fisher et al. 2007; Ghiani et al. 2007; Bhaskar and Govindarajulu 2010; Chiou et al. 2010). Fisher et al. (2007) argue that the use of mobile devices such as tablet PCs in education can enhance the teaching experience of lecturers as well as the quality of the learning experience of students. The research by Shih et al. (2010) indicates that using mobile learning helped lower the cognitive load of students with low achievement rates.

A large area of context-aware mobile learning research has been focused on museums and tours in providing information based on the person's location (Reynolds et al. 2010; Chiou et al. 2010; Yatani et al. 2004; Costabile et al. 2008; Park et al. 2007; Hsu and Liao 2011). According to Reynolds et al. (2010), many students appreciated the contextual information offered by the mobile device which encouraged them to ask more questions. This enhanced their knowledge about the objects in the museum.

From a pedagogical perspective, context-aware and location-based mobile learning is clearly related to the situated learning theory: It is important to gain an understanding of this in order to learn how to optimise the development and implementation of context-aware and location-based applications.

2.2 Situated Learning

Lave and Wenger's (1991) situated learning paradigm states that the situation in which learning occurs has a great effect on learners. They argue that learning must not be abstract and out of context. It is situated and takes place within the context, activity, and culture in which it occurs as a "legitimate peripheral participation" process. Lave and Wenger (1991) emphasise social communication and interaction as being significant parts of situated learning. Learning should be presented in an authentic setting supporting knowledge exchange between learners (Naismith et al. 2004).

Definitions of the key characteristics of situated learning differ depending on the technology (Yusoff et al. 2010). When designing situated learning using mixed-reality technology, Yusoff et al. (2010) outline three main elements: authentic context, authentic activity/task, and users' collaboration. Lunce (2006), in designing situated learning using simulation, suggests four criteria for situated learning: A specific context that impacts learning must be defined, peer-based interactions and collaboration between students must take place, knowledge is tacit, and tools must be used to accomplish real-time objectives.

Herrington et al. (2000) propose the following elements for situated online learning using multimedia: “authentic contexts and activities, access to expert performances and the modelling of processes, multiple roles and perspectives, collaborative construction of knowledge, coaching and scaffolding, reflection to enable abstractions to be formed, articulation to enable tacit knowledge to be made explicit, and integrated authentic assessment”.

In summary, there is agreement that although technologies differ, for a successful learning experience, situated learning has to take place in an authentic setting, with authentic contexts and activities. Therefore, it is vital that this research is aligned to, and integrated into, real teaching and learning scenarios to ensure validity. Additionally, facilitating collaboration between learners can be an important enhancement of the learning experience.

2.3 Critical Thinking

As this research proposes to encourage and develop students’ critical thinking and analysis, it is important to define what this means. There are several relevant definitions of critical thinking, some as early as Dewey (1933). However, for the purposes of this study, one definition has been identified, that of Scriven and Paul (1987), who defined it as “the intellectually disciplined process of actively and skillfully conceptualizing, applying, analyzing, synthesizing, and/or evaluating information gathered from, or generated by, observation, experience, reflection, reasoning, or communication, as a guide to belief and action”. Their definition shows a clear relation to Bloom’s taxonomy, as it connects critical thinking to the three higher levels of the taxonomy (analysis, synthesis, and evaluation; Duron et al. 2006). This definition emphasises the multifaceted nature of critical thinking, expressed through a number of activities. These activities correspond to the assessed work carried out by students in this study, explained in Sect. 3.

3 The Situated Learning Problem Domain

HCI studies the way people interact with computers in a particular context and evaluates the extent to which these computer-based systems are, or are not, designed for successful interaction. Students taking HCI modules usually learn about various interface design constraints and the way HCI is affected, as well as the relationship between the interaction and the context of use. They are required to know the potential users of the systems and their goals in order to create a system that is effective, efficient, and intuitive. Moreover, they learn about the user-centred design methods that require the involvement of the user in the whole process of the system development cycle. This deep understanding of the needs and requirements of the users leads to iterative prototyping and evaluation.

This intervention aims to resolve issues faced by students when learning in a real-world situation. The initial situated learning activity is being developed for a level 2 HCI module in the Department of Computer Science and Creative Technologies at the University of the West of England (UWE), Bristol, UK. As part of their work for this module, students are required to evaluate and carry out a context-based analysis as part of a requirements gathering process for a computer-based system. The requirements gathering process involves exploring opportunities for a technological intervention, ensuring that the solution developed will suit the particular situation/users. The emphasis is thus on gaining a really deep understanding of the people involved, their activities, and the context. The student designer needs to consider the question: "What are the opportunities, constraints, and barriers within the situation that need to be addressed?"

To facilitate this, the People, Activities, Context, and Technology (PACT) framework is used to prompt students to consider specific categories in their analysis. The elements of the framework are described by Benyon (2010):

1. People: They differ physically, psychologically, and in terms of their knowledge of technology.
2. Activities: They differ in terms of temporal aspects (response time, frequency of the activity, time pressure and peaks), cooperation, complexity, and safety criticality.
3. Contexts: The different environments in which the activities take place encompass the organisational and social context and the physical environment.
4. Technologies: These should reflect the specific issues identified in considering the previous elements; features include input, output, communication, and content.

The students' brief is to go into specific environments relevant to their design task and to collect data regarding the first three elements of the PACT framework using mainly observation but also formal and informal interviews, questionnaires, and focus groups. They then need to analyse critically the data collated in order to identify possible opportunities, constraints, and solutions.

As stated earlier, our research is seeking to investigate a mobile location-based system to support the students' activity for this task. The next section details our findings from the requirements gathering work carried out.

4 Research Methodology

The research involved two phases: requirements gathering and the development of a theoretical framework.

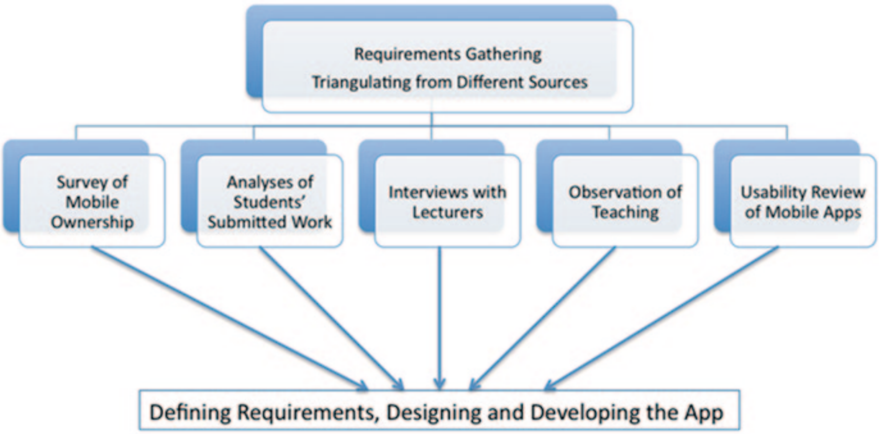


Fig. 10.1 Requirements gathering methodology

4.1 Phase One: Requirements Gathering

Requirements gathering is a significant part of any user-centred design (Lazar et al. 2010); it aims to establish a deep understanding of the situation, to refine the user requirements, and to identify the functional and non-functional requirements of an application. In order to improve validity, a range of approaches was used, enabling us to triangulate the findings as part of the analysis. This was guided by a contextual inquiry method as described by Holtzblatt and Beyer (2013). The approach includes a survey of mobile ownership, the analysis of the students' submitted assignments, interviews with the lecturers, observations of teaching, and a usability review of mobile apps (Alnuaim et al. 2012). Figure 10.1 illustrates this approach.

Survey of Mobile Ownership and Practice

It is significant for this research to know the current status of students' mobile phone ownership and practice. We therefore carried out a survey, aiming to:

1. Investigate the university students' ownership and usage of smart phones
2. Explore the potential of using mobile smart phone devices for learning

It is vital to understand whether the students are prepared and willing to use their mobile phones for learning and to what extent.

Response to Survey Eighty-eight students filled out an online questionnaire about their ownership and use of mobile phones, of whom 58 were undergraduate students aged between 17 and 30 years and 30 postgraduate students aged between 22 and 50 years. Of the 88, 60 were males while 28 were females. The questionnaire was

Table 10.1 Operating systems

		Frequency	Percentage
What operating system is running on your device?	iOS	23	26.1
	Android	28	31.8
	Blackberry	14	15.9
	Symbian	2	2.3
	I do not know	21	23.9
	Total	88	100.0

distributed to them through the students' union and through the lecturers of the HCI module.

Materials and Procedure The questionnaire consisted of 15 questions in three sections. Five demographic questions about their age, gender, faculty, and course were asked; six questions were asked about privacy issues, global positioning system (GPS) usage, and whether they were prepared to share their location with peers and lecturers; and an optional open-ended question was included for any further comments.

Survey Results

Mobile Devices' Ownership Upon analysing the questionnaire, it was found that the two major operating systems for smart phones used by students were Android and iOS. Android-based mobile phones were owned by 32.2 % of the students while 26.4 % owned an iOS Apple iPhone. However, 23 % of the students were not sure what operating system was running on their phones. Table 10.1 shows the distribution of the operating systems.

Data Usage When asked about their data usage, 58.9 % of the students had a data contract while 40.2 % did not. Of 58.9 % who owned a data contract, 90.2 % thought that their data allowance was adequate.

Privacy Issues This section was crucial to understand the students' current practice regarding GPS-enabled applications and whether they were ready to share their location with their fellow students and lecturers. The survey showed that 73.2 % of students do not use GPS-based location applications, such as Foursquare (Foursquare Labs 2013). When asked about the reason behind this, 50.8 % said they never needed to, 42.4 % said because they liked their privacy, and 15.3 % were not interested in social networks. However, of 26.8 % of the students who used GPS-based applications, only 26.1 % used them openly, while 65.2 % limited access to friends and family. When asked whether they were prepared to use GPS-based location applications for learning purposes (with fellow students and/or lecturers), requiring them to reveal their location through the application to exchange and share knowledge on a particular assignment, 42 % agreed that they would use such an application, sharing location information with both students and lecturers, 12.3 % said they

Table 10.2 Mean ranks for gender

	Gender	*N*	Mean rank
Would you be prepared use GPS-based location apps for learning	Male	60	41.01
	Female	28	51.98
	Total	88	

would share with students only, 8.6 % said they would share with lecturers only, while 37 % indicated that they would not like to share their location data. When asked about the reason behind it, 66.6 % were worried about privacy while 33.3 % did not see the relevance of using such an application in learning.

Statistical Analysis of Privacy Issues To know whether there was a significant difference between the mean responses of the sample due to faculty, course, type of study, age, and gender, non-parametric tests were applied as the data do not follow the normal distribution. The Kruskal–Wallis test was used between three or more groups of data while the Mann and Whitney test was used between two sets of data.

A Kruskal–Wallis test found that there were no statistically significant differences in the response of respondents of the privacy issues questions due to their faculty, the course, and their age as the potential value (Sig.) for all areas was greater than the significance level (0.05).

Moreover, the Mann and Whitney test found that there were no statistically significant differences in the response of respondents to the privacy issues questions due to their type of study (undergraduate or postgraduate). However, when looking at gender, there was a statistically significant difference in their answer to the last question on privacy issues (Would you be prepared to use GPS-based location applications for learning purposes?) depending on their gender. The potential value (Sig.) was $0.045 < 0.05$. Table 10.2 shows the mean ranks.

Discussion The analysis of this questionnaire shows that the two preferred operating systems were iOS and Android. Android has a slightly higher preference with a percentage of 32.2 % compared to 26.4 % for iOS. This finding influenced the choice of which operating system should be used when implementing the application for this research. The analysis showed, as well, that students care about their privacy and would not easily compromise it. A high percentage of 73.2 % of the students are not using location-based social applications whereas 42.4 % pointed out that privacy was the reason for not using such applications. What is more, only 42 % of students said they would be prepared to use a location-based social application for learning purposes. This finding is especially of interest as it influences the choices for functionality and design of the application for this study.

Analysis of Students' Submitted Assignments

The undergraduate students participating in this study were in their second year of the web design course in the Department of Computer Science and Creative Technologies at the University of West of England. They were required to submit

Table 10.3 Issues and occurrences

Issue ID	Issues	Total number of occurrences
A	No clear links of the issues discussed in P, A, and C with technologies	17
B	Some issues were not related to the right element of PACT	11
C	No real consideration of the human factors	10
D	Issues were general and not mainly context related	6
E	No links of the issues discussed in P, A, and C with technologies	8
F	Gave the issue with the solution rather than putting the solution under technologies and linking it to P, A, or C	10
G	Need more thoughtful consideration of the context	5
H	Need to address issues found under each PACT element	3
I	Technology issues could be expanded	3
J	Linking should be more explicit	6
K	Need to find solutions to current problems, not eliminate ideas because of that problem	2
L	Need to think about and address issues from observations and experience	1
M	Need to identify issues under each P, A, and C and then see what T can allow for the proposed self-checkout not for the cafeteria	4
N	Need to consider human factors in more depth	4

a portfolio of small assignments. Out of 48 students, 47 submitted the part of the portfolio considered here. The work of these students was looked at carefully and analysed. Each student's work was separately scrutinised to identify his/her weaknesses and any good practice. It is crucial to know how common a particular issue is among the students to gain an understanding of whether that issue needs to be considered when designing and developing the application. The analysis was verified by checking its correspondence with written feedback from the lectures on each aspect of their work.

For anonymity, each student was given a number from 1 to 47. The number of times an issue occurred in each assignment was counted. Table 10.3 shows the issues identified and occurrences.

In this table, we can see that 36 % of the students had difficulties linking the characteristics of the people, activities, and context identified to technologies. In other words, they should have identified the technologies that would serve the characteristics of the people carrying out certain activities in that particular context. Moreover, 23 % of them had issues with understanding the PACT framework itself. However, it should be noted that the lecturers had not put a great deal of emphasis on this, as mentioned in the section "Observations of Teaching". It is clearly im-

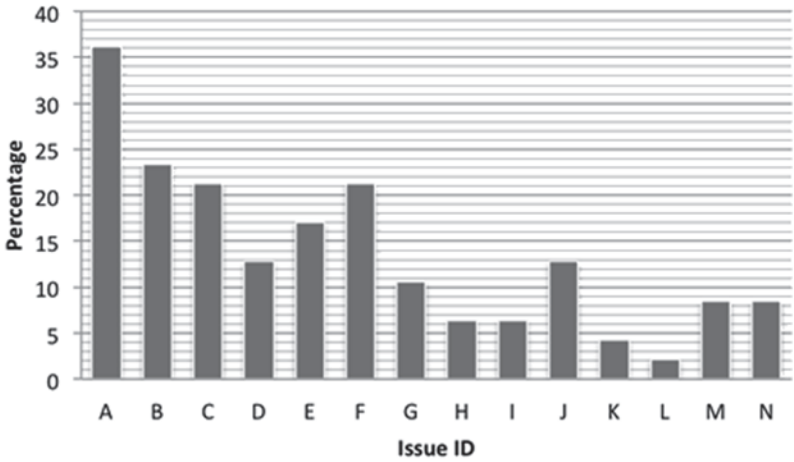


Fig. 10.2 Percentages of the occurrences of issues

portant to consider the people who will be using the technology; nevertheless, 21 % of students did not give this much attention. Figure 10.2 shows each issue with the corresponding percentage of students to whom this applies.

As future work, we hope to organise a focus group to elicit further information about the difficulties encountered by students from a pragmatic point of view, and the functionality that they would wish to see in the application to help them overcome these difficulties. We also hope to cross-reference this information with the information obtained from the students' coursework analysis presented above.

Interviews with Lecturers

Our aim was to explore the following issues with the lecturers teaching the HCI module:

1. Their current practice of teaching students, especially concerning the PACT framework
2. Their current approach to explaining assignment to students
3. The students' current practice in completing the assignment, the difficulties they encounter, and the reasons behind these difficulties from the lecturers' point of view
4. What they hope this intervention will achieve

A series of unstructured interviews with two lecturers teaching the HCI module was carried out. This is a significant part in the requirements gathering as it highlights clearly the functionality of the application that needs to be considered.

In-Class Teaching

In the HCI module, students learn about how people undertake activities in context using technologies. They apply the PACT framework to analyse situations in order for them to design interactive systems (Benyon 2010). The lecturers explain the PACT framework in detail to students, giving them specific examples to clarify the concept. These include scenarios such as: (a) a female student using her smart phone to send a text message while on a moving bus, when she is seated, when she is standing holding on to a bag and an overhead strap for balance, and when the bus is extremely crowded and (b) an elderly woman setting her burglar alarm which is located in a dimly lit passageway, with situations where the elderly woman has different age-related conditions. These example scenarios are formulated to support the students in understanding the elements of the framework. Photographs are shown to provide students with a realistic view of the physical environment and they are encouraged to discuss the issues and draw on their own experiences where appropriate. However, the weakness is that the students are not able to immerse themselves in the actual environment to get a tangible understanding of the constraints and therefore fail to develop empathy for the users.

Practical Learning Activity

As part of one of their assignment activities, students are required to conduct a requirements study for the design of a new technology. In the past, this has included the design of a university information kiosk and a digital guide for a music festival. This year, students were asked to consider the design of a self-service checkout for use in a cafeteria. Using the "PACT" framework, students were required to analyse the factors that they would need to take into account in designing such a system. They were required to gather data for the analysis via observations of the OneZone cafeteria (Main University Cafeteria at UWE) at various times, to consider their own experiences, as well as to conduct short interviews with at least three stakeholders.

Students were then required to present their findings as a mind map, ensuring that there were clear links between the People, Activities, and Context elements and the Technologies considered. They needed to explain in separate paragraphs and in relation to each element of the PACT framework, why the points that they had noted were of significance.

This was explained to the students in class and described on their coursework assignment specification alongside the marking criteria.

The Students' Current Practice in Completing the Assignment from the Lecturers' Point of View

It is crucial to investigate the lecturers' understanding of the students' current practice, the difficulties they encounter, and the reasons behind it from their point of view. Lecturers' assessment of the work gives them the impression that some students get distracted by the environment and sometimes forget the main purpose of their assignment. From their experience, students miss out key details when carrying out their analysis, leading to a disconnected analysis, especially between the elements of PACT. Moreover, students tend to forget that "people undertake activities in context using technology"; as a result, they fail to consider the implications of what they have identified for each of the elements, People, Activities, and Context, in relation to the Technology. They thus miss the purpose of their assignment, to analyse the situation and consider technologies that reflect peoples' needs when carrying out certain activities in a particular context. In some cases, students fail fully to engage with, or appreciate the relevance of going to the location at all, and complete the activity in a rushed manner with little or no reflection.

The Lecturers' View of the Intervention

The lecturers want this mobile application to assist students when carrying out their analysis. They want it to provide students with prompts when they are at the location. These prompts should address the students' weaknesses already identified by the lecturers and also from the analysis of the previous students' assignments, discussed earlier in the chapter. The lecturers suggest that the students should be able to capture images using the application, take notes, and track their own progress.

Observations of Teaching

In addition to the interviews with lecturers, observation of teaching was conducted. This gave us a better understanding of the current practice. Attending HCI lectures was a valuable part of the research, giving an insight into how students engage with the lectures and what questions they might raise about the PACT framework and the assignment. Observing the collaboration forum on Blackboard was also useful, revealing students' queries and concerns and the feedback given by the lecturers. Students queried the scope of the elements of PACT and the relationship between the different elements. Their queries raised significant questions regarding the use of the framework that needed resolving: To what extent is it necessary to encourage students to use the PACT elements correctly? Is it a tool for bringing to light a large number of factors or do we value it as a categorisation tool? It was important to discuss these two issues with the lecturers. Following discussion, it was agreed that we should remind students of the PACT elements without putting undue emphasis on categorisation.

Usability Review of Mobile Apps

As a part of the requirement gathering, a usability review of mobile applications was conducted. This review gave an understanding of what usability issues students might encounter when using such an app, and how the educational features should be configured given any constraints of the technology.

Examining a range of apps and designs has highlighted the following issues which, using the PACT framework ourselves, we have consolidated into the four different categories.

People:

The main users of our app will be higher education students. However, students still vary. They might have:

1. Physical differences such as size of hands and impairments (visual, hand, and finger movement)
2. Psychological differences such as learning style preferences, different capacity for remembering things, varying levels of stress and frustration

Activities:

Since the app is meant to be used in situ, there are a number of aspects that should be considered:

1. Temporal Aspects: The app will be used at different times of the day where the environment could be busy or quiet. Interruption is likely to occur and the student should be able to return to same point pre-interruption. The app's response time should be adequate.
2. Cooperation and Complexity: The app is meant to be used by one student; however, the content may be shared and so should be easy to access for all students. Contribution of data in any shared space should be clearly attributed to the student who made the submission.
3. Content: To solve the issues identified in Table 10.3, the content should be considered carefully to address these weaknesses, the text and images should be clear, should provide the ability to take photos, and write notes.

Context:

1. Physical Environment: The app could be used indoors or outdoors, in different light and weather conditions.
2. Social Context: Students may prefer to be in pairs or groups and the environment might be crowded and noisy.
3. Organisational Context: When looking at what the app might provide regarding the educational institution, it should not add to the lecturers' workload, it should improve students' knowledge and learning, and it should be cost effective from a teaching resource perspective.

Technologies:

Now that we have identified the above, they can be associated with appropriate technologies:

1. Input:
   a. Touchscreen: clear and adequately sized buttons to cater for the physical differences

   b. Text: ability to type in notes and observation and allow editing, mistakes that might happen due to interruption or busy environment
   c. Images: the ability to capture photos using the integrated camera on the smartphone

2. Output:

   a. Text: must be of a good size, with hints written in language that supports different abilities
   b. Images: should coordinate with the appropriate notes
   c. Auditory: must be kept to a minimum due to the environment

3. Communication: fast response time, Internet connectivity, allow for service interruption, and provide feedback as appropriate

4.2 Findings

This section will explain the insights gained so far. It also explains how we are translating these into design features.

Students lose focus on the purpose of tasks when away from the classroom. They may get distracted by their surroundings and miss out key elements. So, a key feature of this mobile application could be to remind students of the purpose of their learning and to support their progression through the activities in a personalised manner.

When students reach a pre-specified location, the application should display a detailed map identifying the various sub-locations and containing either text and/or images. These hints could be designed to aid them in widening their perspectives, in developing their own ideas, and in critical evaluation. The text notes could vary from simple instructions and prompts to questions and in some cases to links that will open a quiz webpage; the particular content would depend on the specific aspect that the lecturer wanted the students to focus on.

It is important to encourage students to think of issues beyond their own experiences and perspectives. Providing students with functionality to share comments, ideas, and perhaps stories if desired may enable them to benefit from their peers' knowledge and different perspectives. Adding a collaborative learning aspect to the activity, students will be able to share their comments with their lecturers and fellow students.

Students have varying levels of ability when it comes to design thinking, and they work at different rates. A mobile application such as this provides opportunity for personalised learning; these include paced progression, checklists to give a sense of achievement and motivation, and structured disclosure, based on the students' level of interaction with the application.

Some students have been found to struggle in analysing their findings and specifically in using their findings to develop new ideas. Prompting them with probing questions that challenge their assumptions or get them to explore other methods of requirements gathering, beyond observation, could help them identify innovative opportunities. This approach could also address the problem of their failing to identify appropriate technologies for the specific characteristics identified in the earlier analysis.

4.3 Phase Two: Theoretical Framework Development

This phase focused on developing a theoretical framework for the project (named sLearn) based on the findings of the previous phase, the requirements' gathering, and the literature review.

A number of existing general frameworks have been examined to choose the most relevant one for this research. We have chosen the work of Ryu and Parsons (2008) as an appropriate framework for developing the theoretical framework for the requirements. This was primarily because of the way the framework was designed, addressing both technical perspectives and learning perspectives. For the students to benefit from the mobile learning experience, it is vital to have a clear understanding of the different design requirements and the relationships between them. Moreover, this framework addresses the learning activities that this research is most interested in, situated, collaborative, and individual learning activities. Careful consideration was taken when designing the actual learning activity for this research. It was significant to try to incorporate all characteristics of mobile learning identified in the literature. Lee and Lee (2008) defined mobile learning as being situated, learner-centred and spontaneous, customised, connected, and flexible. The proposed mobile application allows students to learn in situ at their preferred time, giving them the ability to observe and note, connecting them with their peers, and giving them some hints. The hints provided by the app are there to guide but not limit. Figure 10.3 shows the design framework for the mobile learning activity in this research.

As the above framework shows, this activity is designed for higher education students investigating real-world situations. The sLearn application will be developed initially for Android-based smart phones where the interface needs to provide the student with a map and/or images of the area investigated, hints from lecturers, and textboxes to save his/her notes. Students will visit the area at different times based on their preference. The mobile communication method would be either the carrier network or Wi-Fi if available. Having special hints for each location provides students with contextual knowledge. Having the ability to type in their observations will allow them to analyse their notes at a later time and generate new ideas, which would mean improved knowledge. Moreover, having the ability to share their observations with their peers allows for social knowledge.

Many modules require students to investigate real-world scenarios, so this framework needs to be flexible to enable deployment in other similar learning contexts. Table 10.4 describes the situated learning activity of this research. This analysis is

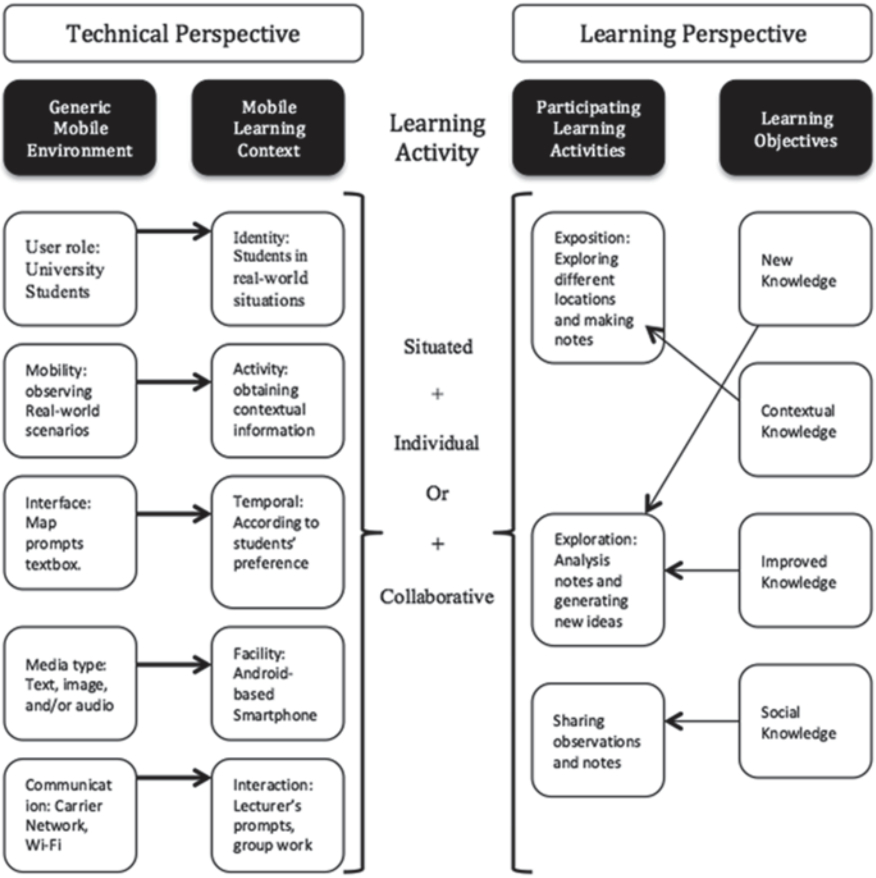


Fig. 10.3 sLearn's activity design framework

related to the design framework shown above and has been derived from Parsons et al.'s (2007) analysis of previous projects.

It is important to consider carefully the types of prompts to be provided to the users of this mobile application, higher education students. At this level prompts should only give some hints to the students regarding what they should look for and observe or investigate. They should be able to develop their own understanding of the situation and develop their own insights. These expectations should be clearly explained to students prior to the activity.

Drawing on the findings from the requirements gathering outlined earlier and the theoretical framework, helped to define the activity, functional, and non-functional requirements for the application which have been defined in Tables 10.5 and 10.6.

It is envisaged that the app will be designed to function as follows: When the student reaches a pre-specified location, the application will display a detailed

Table 10.4 Analysis of situated learning activity using sLearn

Objectives	Learning experience	Learning context	
Individual learning: (Improving Skills) Observations and investigations, reflection, and analysis	*Organised content*: For different locations, different things to look for and observe/investigate	*Identity*: HE students (under/post graduate)	*User roles*: Students observing/investigating, collecting information
Collaborative learning: Communicating ideas, consolidating	*Outcome and feedback*: Notes observations/investigation saved and shared if desired	*Activity*: To go to a predefined location and carry out observation/investigation activities and collecting data to further analysis and discussion	*Mobility*: Smartphone
	Goals and Objectives: To observe/investigate real-world scenarios To analyse what was observed To discuss and reflect on findings	*Spatial-temporal*: Predefined location, at a time of students' preference	*Interface design*: Photo of the location, lecturer's prompts/hints, capturing images, taking notes, collaboration support.
	Conflict, competition, Challenge, opposition: Discussing the analysis and finding	*Facility*: Smartphone application. Initially Android-based smartphone	*Media*: Images/texts
	Social interaction: Peer/group forum to consolidate findings	*Collaboration*: Lecturer's prompts/questions, going with peers	*Communication*: Cellular data, Wi-Fi

HE higher education

map identifying various sub-locations. On selecting a sub-location, guidance, hints, or "prompts" provided by the lecturers in the form of text and/or images associated with each sub-location will be displayed. This guidance will be designed to ensure that the issues listed in Table 10.3 are fully addressed when the students conduct their observations using the app. The prompts will vary from comments to questions, the particular content being dependent on the specific aspect that the lecturer wants the students to focus on. Furthermore, there will be a collaborative learning aspect to the activity: Students will be able to post their comments for their lecturers and fellow students to take note of. Moreover, lecturers have pointed out that some students perform the activity without a thorough consideration of the issues. Providing students with information, through the app, regarding the time they spend doing the activity may help them become more aware that they might not have devoted sufficient attention to the task.

Table 10.5 Functional requirements

Requirement number	Description
F1	The user should be able to choose different locations to check the prompts
F1.1	The user should be able to read the prompt(s) associated with the chosen location
F2	The user should be able to write his/her own comments in response to each prompt within each location
F2.1	The user should be able to share his/her comments
F3	The user should be able to capture images
F4	The user should be able to get back to the main map
F5	The user should be able to get back to same point when interrupted by a call, text, etc.
F6	The system should allow the user to know which prompts within each location he/she had already visited/observed
F7	The system should calculate the time spent on each location
F8	The system should provide the user with data to track his/her progress

Table 10.6 Non-functional requirements

Requirement number	Description
N1	The system should be easy to learn
N2	The system should be intuitive
N3	The buttons should be of a good size
N4	The images should have high contrasting colours
N5	The system should be light to give fast responses

5 Conclusion and Future Work

Application-focused research into mobile situated learning in higher education is rapidly growing. Our research has the potential to add to the understanding of how mobile applications can assist students learning in situ and to develop analysis and critical thinking skills. In order to develop applications of this type, it is important to consider the issues associated with the learning experience from a range of perspectives. In this study, we have conducted interviews with the lecturers of the HCI module, observed the teaching process, both face to face and via discussion forums, and analysed the students' submitted assignments; these data have highlighted the specific difficulties that students encounter and thus helped establish the functional and non-functional requirements to be considered when designing and developing the mobile application. We are continuing with the research, adopting a user-centred, iterative approach to the design. We are currently working on the first prototypes of our application and will evaluate these applying usability criteria such as how easy the features of the application are to understand, the app's learnability, and the effectiveness of feedback and the ease of interaction.

It is envisaged that providing students with a mobile application with structured guidance will be particularly helpful for those who need additional support in analysing a situation in a logical manner. Being able to have this structured support available outside of a classroom will enable access to their formal learning in an informal setting, which they can complete at their own pace. Enabling access to their peers' notes and observations should also help students in consolidating their knowledge, drawing on the expertise of other students with different perspectives, and encouraging collaborative learning.

References

Abowd, G., Dey, A., Brown, P., Davies, N., Smith, M., & Steggles, P. (1999). *Towards a better understanding of context and context-awareness*. HUC '99 Proceedings of the 1st international symposium on handheld and ubiquitous computing, Karlsruhe, Germany, pp. 304–307.

Alnuaim, A., Caleb-Soly, P., & Perry, C. (2012). *Location-based mobile learning for higher education students—devloping an application to support critical thinking*. Proceedings of the 11th international conference on mobile and contextual Learning 2012, Helsinki, Finland.

Barkhuus, L., & Dey, A. (2003). *Is context-aware computing taking control away from the user? Three levels of interactivity examined*. Proceedings of UbiComp 2003, Seattle, Washington, pp. 150–156.

Benyon, D. (2010). *Designing interactive systems* (2nd ed.). Reading: Addison-Wesley.

Bhaskar, N., & Govindarajulu, P. (2010). Advanced and effective learning in context aware and adaptive mobile learning scenarios. *International Journal of Interactive Mobile Technologies, 4*(1), 9–13.

Brown, E., Börner, D., Sharples, M., Glahn, C., de Jong, T., & Specht, M. (2010). *Location-based and contextual mobile learning in deliverable contribution small scale study*. STELLAR.

Chiou, C., Tseng, J. C. R., Hwang, G., & Heller, S. (2010). An adaptive navigation support system for conducting context-aware ubiquitous learning in museums. *Computers & Education, 55*(2), 834–845.

Costabile, M., De Angeli, A., Lanzilotti, R., Ardito, C., Buono, P., & Pederson, T. (2008). *Explore! possibilities and challenges of mobile learning*. Proceeding of the 26th annual CHI conference on human factors in computing systems CHI 08, Florence, Italy, pp. 145–154.

Dewey, J. (1933). *How we think*. Boston: DC Heath and Co.

Duron, R., Limbach, B., & Waugh, W. (2006). Critical thinking framework for any discipline. *International Journal of Teaching and Learning in Higher Education, 17*(2), 160–166.

Fisher, L., Callaghan, M. J., Harkin, J., & McGinnity, T. M. (2007). Using situated learning theory to explore tablet PC use in academic work: Perceptions of staff and students. *IADIS International Journal on Computer Science and Information Systems, 2*(2), 99–109.

Foursquare Labs, Inc. (2013). https://foursquare.com/. NY, USA. Accessed 1 Oct 2013.

Ghiani, G., Paternò, F., Santoro, C., & Spano, L. D. (2009). UbiCicero: A location-aware, multi-device museum guide. *Interacting with Computers, 21,* 288–303.

Herrington, J., Oliver, R., Herrington, T., & Sparrow, H. (2000). *Towards a new tradition of online instruction: Using situated learning theory to design web-based units*. Paper Presented at AS-CILITE Conference, Coffs Harbour, Queensland.

Holtzblatt, K., & Beyer, H. R. (2013). Contextual design. In M. Soegaard & R. F. Dam (Eds.), *The encyclopedia of human-computer interaction* (2nd ed.). Aarhus: The Interaction Design Foundation.

Hsu, H., & Liao, H. (2011). A mobile RFID-based tour system with instant microblogging. *Journal of Computer and System Sciences, 77*(4), 720–727.

Kelley, J. F. (1984). An iterative design methodology for user-friendly natural language office information applications. *ACM Transactions on Office Information Systems, 2*(1), 26–41.

Kinshuk, Chang, M., Graf, S., & Yang, G. (2009). *Adaptivity and personalization in mobile learning*. In 2009 AERA Annual Meeting San Diego, CA, USA., April 13–17.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge: Cambridge University Press.

Lazar, J., Feng, J. H., & Hochheiser, H. (2010). *Research methods in human-computer interaction*. West Sussex: Wiley.

Lee, Y., & Lee, S. (2008). Situated Mobile Learning in Higher Education. In C. J. Bonk, Lee, M. Miyoung & Reynolds, T. (Eds.), *Proceedings of World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education.* (Las Vegas, Nevada, USA, November 17, 2008). Chesapeake, VA: AACE, 1745–1750.

Lunce, M. L. (2006). Simulations: Bringing the benefits of situated learning to the traditional classroom. *Journal of Applied Educational Technology, 3*(1), 37–45.

Naismith, L., Lonsdale, P., Vavoula, G., & Sharples, M. (2004). *Literature review in mobile technologies and learning No. 11)*. Bristol: NESTA FutureLab.

Park, D., Hwang, S., Kim, A., & Chang, B. (2007). *A context-aware smart tourist guide application for an old palace*. Proceedings of the 2007 international conference on convergence information technology (ICCIT '07), pp. 89–95.

Reynolds, R., Walker, K., & Speight, C. (2010). Web-based museum trails on PDAs for university-level design students: Design and evaluation. *Computers & Education, 55*(3), 994–1003.

Ryu, H., & Parsons, D. (2008). A learner-centred design of a location-aware learning reminder. *International Journal of Mobile Learning and Organisation, 2*(2), 187–200.

Scriven, M., & Paul, R. W. (1987). *Critical thinking as defined by the national council for excellence in critical thinking*. 8th annual International Conference on Critical Thinking and Education Reform, Summer 1987.

Shih, J. L., Chuang, C. W., & Hwang, G. J. (2010). An inquiry-based mobile learning approach to enhancing social science learning effectiveness. *Educational Technology & Society, 13*(4), 50–62.

Woodill, G. (2011). *The Mobile Learning Edge: Tools and Technologies for Developing Your Teams,* McGraw-Hill, New York.

Yatani, K., Sugimoto, M., & Kusunoki, F. (2004). *Musex: A system for supporting children's collaborative learning in a museum with PDAs*. Paper presented at the Wireless and mobile technologies in education, 2004. Proceedings the 2nd IEEE international workshop on, pp. 109–113.

Yau, J., & Joy, M. (2009) *A mobile and context-aware learning schedule framework from a pedagogical perspective: An interview study*. IADIS international conference mobile learning, pp. 189–196, Barcelona, Spain.

Yusoff, R., Zaman, H. & Ahmad, A. (2010) Design A Situated Learning Environment Using Mixed Reality Technology—A Case Study, *World Academy of Science, Engineering and Technology,* vol. 47, pp. 887–892.

Chapter 11
Developing Technological and Pedagogical Affordances to Support the Collaborative Process of Inquiry-Based Science Education

Manoli Pifarré, Rupert Wegerif, Alba Guiral and Mercè del Barrio

1 Introduction

The understanding of "learning to learn together" (L2L2) is inspired by the real working lives of professionals having to work together with others in teams to solve complex problems and make decisions. For example, when, in April 2010, an explosion in the Gulf of Mexico caused a flow of oil, BP responded by assembling a team of experts to find a solution. This team was not colocated and so they had to work together sharing ideas and co-constructing plans of action supported by web-mediated communication tools. Distributed teams of experts working together to solve problems and inquire into issues are increasingly common in the knowledge economy. Computer-supported collaborative teamwork of this kind is not only a response to time-sensitive crises but also the main means by which new knowledge is constructed in the sciences. However, current education systems do little to equip children and young people with the complex competence of problem solving and learning together with others online. In the case of the 2010 oil spill, the team of experts failed to come up with a successful solution until the oil had flowed for three months, doing great damage to the environment. A lack of technical knowledge may have contributed to this failure, but it is also possible that a lack of knowledge about and experience of learning together effectively may have contributed to this delay. There has been some research on ways to teach for learning how to learn (L2L), which is often referred to as the most important knowledge age skill as it equips people to adapt flexibly in a time of rapid change. However, there has been little research on how to teach for the skills involved in L2L2, which is possibly

M. Pifarré (✉)
Faculty of Education, Department of Psychology and Pedagogy,
Universitat de Lleida, Lleida, Spain
e-mail: pifarre@pip.udl.cat

R. Wegerif
Faculty of Education, University of Exeter, Exeter, UK

A. Guiral · M. del Barrio
Faculty of Education, Universitat de Lleida, Lleida, Spain

D. G. Sampson et al. (eds.), *Digital Systems for Open Access to Formal and Informal Learning,*
DOI 10.1007/978-3-319-02264-2_11,

even more important for surviving and thriving in the knowledge age since most knowledge work is conducted by teams working together rather than by individuals working alone.

As a response to this education and research need, a web-based learning environment has been developed to support collaborative inquiry-based learning in science stimulated by complex real-world questions. It has been developed and trialled in secondary science classrooms but we think that it also has the potential to support learning beyond the classroom. Social networking sites such as Facebook have proved popular but are not equipped with tools that can help groups engage in inquiry-based learning together. The planning tool developed in our project is web based and could support any group in an inquiry into any topic.

This chapter focuses on the development, implementation and evaluation of the web-based learning environment called Metafora[1] which develops a planning and reflection tool using a visual language representing the key components and features required for L2L2 in the context of solving a complex science problem.

Section 11.1 reviews the literature around two axes: (a) inquiry science processes and (b) L2L2 skills. Section 11.2 presents the Metafora platform. Section 11.3 reports the design-based research carried out in secondary schools in Spain in order to gain an understanding about the Metafora's technological and pedagogical affordances to support students' awareness of the key aspects of learning together and the key scientific inquiry processes. Finally, Sect. 11.4 discusses the findings and conclusions of our study.

2 Key Stages of a Dialogic Inquiry Process in Science

2.1 Approaches to Inquiry Processes

Learning occurs through a social process of inquiry (Dewey 1938). There are different ways to approach inquiry. Reflective inquiry seeks to draw attention on the coupling of metacognition and inquiry in the context of solving open-ended, ill-structured investigations in science (Kyza and Edelson 2003). The name "reflective inquiry" thus has a double meaning, and deliberately so. The first meaning is reflection as in thinking seriously about something. The second meaning is to use a mirror to reflect an image of oneself while working (Keating et al. 1996). In the scientific inquiry-based learning context, de Jong (2006) states that children have difficulties in solving general metacognitive problems and fail to regulate their behaviour or plan effectively. Moreover, shared inquiry requires a commitment to open up both literally and metaphorically the necessary time and spaces to try things out, to play with variations, to probe the possibilities for enhancing motivation and learning

[1] "Metafora"—Learning to learn together: A visual language for social orchestration of educational activities. FP7-ICT-2009.4.2 Technology Enhanced Learning, contract no. 257872.

and to take risks in entering new territory (Thomas and Oldfather 1995). Brown and Campione (1996) recognise that participation in an extended process of shared inquiry fosters children's ability to ask complex questions.

The US National Research Council (2000, in Grandy and Duschl 2007, p. 156) strengthened its definition of dialogical processes of inquiry beyond conceptual learning goals and decided to add the following dialogic features to inquiry learning process:

- Responds to criticisms from others.
- Formulates appropriate criticisms of others.
- Engages in criticism of own explanations.
- Reflects on alternative explanations and not have a unique resolution.

The dialogic process of inquiry can also cultivate learners' scientific thinking skills. It can help to overcome the disjunction between newcomer and expert worldviews (Clancey 1989). For example, in a study of physicists' mental models, Roschelle and Greeno (1987) revealed that experts reasoned about physical situations by creating two parallel mental models, one that represented objects corresponding to physical reality and the other that represented objects corresponding to abstract scientific principles. Physicists developed their analyses of physical situations by comparing the predictions of both mental models. The gap between students' and scientists' worldviews is not localized at the level of "concepts" and "misconceptions", but extends throughout the fabric of thinking—including perception, focus of attention, descriptions of the world, practices of interactions with the world, forms of valid knowledge and values.

2.2 Stages of Inquiry Processes

Different theoretical perspectives have approached learning as a process of inquiry and different models of inquiry have been researched and defined. The main objectives of this section are to review, compare and synthesize five relevant models of inquiry as a theoretical base to construct the key stages and variables of the Metafora inquiry process and to design a superset of the visual language to support L2L2 in science.

Table 11.1 summarizes the comparison of the next five inquiry models: Anastopoulou et al. (2009), Shimoda et al. (2002), Schwartz et al. (1999), Llewelyn (2002), Hakkarainen (2003, 2010). The comparison is made in relation to what phases or stages of the inquiry process each model emphasizes and which is the main focus of each model.

As a result of the comparison and synthesization of these five models, we found a general agreement on the importance of six key stages that were shared. These six stages are presented in Table 11.2.

These six stages are introduced in the design of the visual language of the Metafora platform, and through pedagogy, they are taught to the students. The main aim

Table 11.1 An abstract description of the present five perspectives of inquiry process

	Anastopoulou et al. 2009	Shimoda et al. 2002	Schwartz et al. 1999	Llewelyn 2002	Hakkarainen 2010
Phases/stages	Find my topic Decide my inquiry question or hypothesis Plan my methods, equipment and action Collective my evidence Analyse and represent my evidence My conclusion Share and discuss my inquiry Reflect on my progress	Hypothesis Investigate Analyse Synthesize Extend Question and theorise	The challenge Generate ideas Multiple perspectives Research and revise Test your mettle Go public Look ahead and reflect back	Introducing a topic Assessing prior knowledge Providing exploration Raising and revising questions Brainstorming solutions Carrying out a plan Collecting data Organising data Communicating results Comparing new knowledge to prior knowledge Applying knowledge to new situation Stating a new question to investigate	
Focus of the framework	This is a personal inquiry framework. It enables the students to flexibly sequence the activities	This is a generic inquiry circle, named as a sequence of goals to be pursued by learners	This circle is implemented as a technology template to guide learners through case-, problem-, project-based learning	This circle is a constructivist inquiry cycle from a more detailed inquiry approach	This circle represents a sustained process of advancing and building knowledge

of this pedagogy is to help students to define and be aware of the collaborative processes that the team work has to develop in order to solve the science problem.

For each phase, a set of visual language is proposed. This visual language refers to main processes that students might develop in order to fulfil the objective of each stage. In Fig. 11.1, we represent the main stages (*big green squares*) and processes (*small blue squares*) presented to the students in order to solve the science problem. The basic stages students could follow to solve the problem are represented in Fig. 11.1. However, students were strongly encouraged to design their own team inquiry process and should consider the processes to solve the problem.

Table 11.2 Summary of the overlapped key stages between frameworks

Overlapped stages	Anastopoulou et al. 2009	Shimoda et al. 2002	Schwartz et al. 1999	Llewelyn 2002	Hakkarainen 2010
First phase explore and define a question/topic	Find a topic Decide my inquiry question or hypothesis	Hypothesize	The challenge Generate ideas Multiple perspectives	Introducing a topic Assessing prior knowledge Providing exploration Raising and revising questions	Set up the context Present the problem Develop deepening problem
Second phase to create a solution/hypothesis to the problem	Plan my methods, equipment and actions	Investigate	Research and revise	Brainstorming solutions	Create working theory New theory
Third phase to test a solution and refine the solution	Collect my evidence	Investigate	Test your mettle	Carrying out a plan Collecting data	Critical evaluation
Fourth phase to analyse the results or outcome of the tested solution	Analyse and represent my evidence	Analyse	–	Organising data	Critical evaluation
Fifth phase to make conclusion and present to the public	My conclusion	Synthesize	Go public	Communicating results	Not applicable, because this framework views the whole process through distributed expertise
Sixth phase to reflect and make transfer	Share and discuss my inquiry Reflect on my progresses	Extend Question and theorise	Look ahead and reflect back	Comparing new knowledge to prior knowledge Applying knowledge to new situation Stating a new question to investigate	Critical evaluation Searching Deepening into the knowledge

3 Key Aspects of Learning to Learn Together

L2L is often referred to as the most important knowledge age skill since it equips people to adapt flexibly in a time of rapid change. However, we argue that the reality of Internet-mediated learning is more about L2L2 with others than about learn-

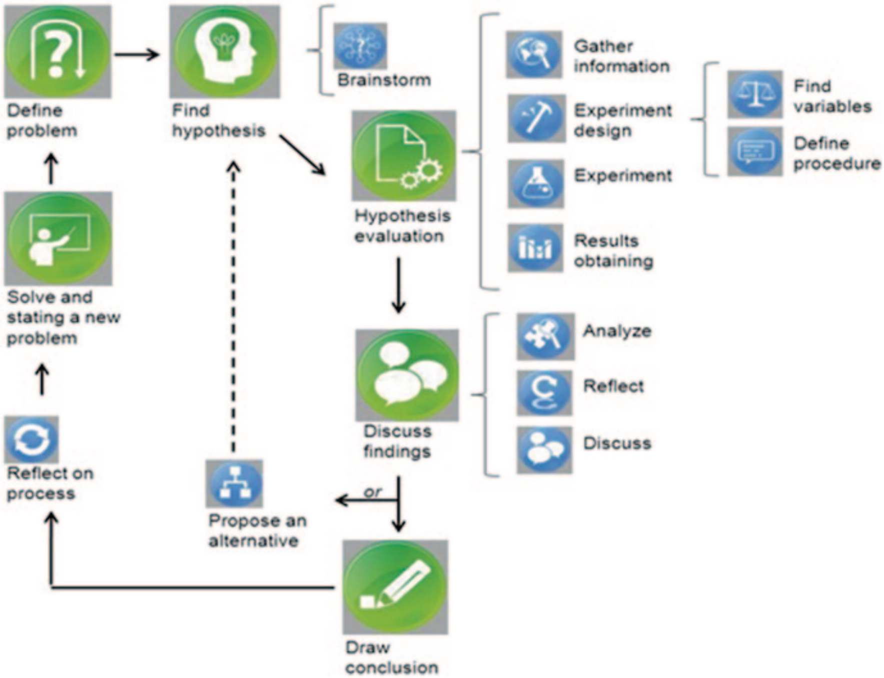


Fig. 11.1 The main visual language icons developed in the Metafora project

ing to learn as an individual. Much knowledge work is conducted by teams and not only by individuals. L2L2 goes beyond L2L because it combines the dimension of task management (how to organise complex inquiries with multiple stages and strands) with the dimension of social relationships (working with attitudes, expectations and identities in order to participate constructively in learning as a collective accomplishment).

Educational research has indicated that collaboration can improve the quality of the learning process and learning outcomes. There is a broad range of types of supporting tools specifically aimed at helping students carry out learning tasks. Research has also shown that simply putting children into groups and leaving them to solve problems with a tool by themselves is not enough to ensure that they will use cooperation and dialogue to good effect. Tools need to be combined with appropriate pedagogy that prepares students for learning together and supports them while they do this.

For groups to be able to create a space of dialogue in an online learning environment and think together requires a learning process that focuses on more than just the task alone. Participating in group work and collaborative learning requires social skills that people also have to develop (De Laat 2006). Students are expected to learn constructively through dialogue with each other and collectively they are, to some extent, made responsible to take charge, control and manage the group's activity. Studies have shown that students need to be able to negotiate aspects of group work such as making plans, setting goals, discussing rules of engagement, responsibilities and expectations. Vonderwell (2003) found that network learners actively coordinated their learning by agreeing on rules, deadlines and responsibilities. Learners, according to Vonderwell (2003), needed to learn to adapt in order to gain learner autonomy as well as to learn strategies for effective collaboration. Hammond and Wiriyapinit (2004) also reported that the participants were actively scheduling their activities and assigning roles within the group as well as exploring the content and reflecting on the nature and purpose of group work. Therefore, besides developing a sense of community in which they get to know each other, build a climate of trust and promote group well-being, learners need to develop group-regulation skills to be successful as a learning community. When students are managing their group learning, they require awareness of each other's learning styles and strategies. L2L2 therefore involves a form of social metacognition that extends knowledge about oneself as a learner to include knowledge about all the members of the group as learners and how these members work together.

In summary, L2L2 is regarded as a complex competence that requires that all the group members are able to coordinate, regulate and plan the learning task by balancing issues of individual ability, motivation and expectations through constant dialogue.

Viewed through the analytic lens of the group or collective, in our study, through pedagogy and the visual language, we have promoted the students' development of the next four L2L2 skills (Yang et al. 2013):

Encouraging Distributed Leadership Moves Leadership is not just the job of the leader but it also requires the cooperative efforts of others (Hollander 1978). To view leadership as a reciprocal social process instead of the property of an individual, leadership responsibilities are shared within the group, and there may be no sharp boundary between leaders and followers (Li et al. 2007).

Distribution of leadership in groups has both social (e.g. Crow et al. 2002) and situational (e.g. Steed et al. 1999) aspects. In our work, each activity stage of the visual language represents a snapshot of the group learning situation, which reveals a need for different kinds of leadership distribution pattern. All students should be able to constantly negotiate the distribution of leadership according to situational and social change. This awareness of distributed leadership around particular topics breaks down dominating coalitions, hierarchical relationships, social exclusion and isolation.

Being Mutually Engaged Through/Around Shared Objects Mutual engagement ensures the coherence of a community over time and is therefore an essential component of any practice (Wenger 1998, pp. 737–735). Shared object/artefacts provide a rich repertoire of referential anchors for mutual engagement and understanding. Crook (1994) argues that there is a developmental line from children's secondary intersubjectivity and symbolic play to sophisticated reciprocal understanding and shared knowledge. In children's symbolic play, the material world plays a crucial role in the coordination of play activities and in creating a shared framework for collaboration. In our work, the shared model of the group learning process, which is made explicit using the visual language, plays a crucial role in supporting mutual engagement and creating a shared framework for collaboration.

Peer Feedback and Evaluation In our work, the first direction is the evaluation done between peers when they work together (c.f. peer assessment). Peer evaluation is done while students work together using the planning or discussion tool and by sending messages with the message tool. Students could use different tools to give peer feedback. For example, feedback related to L2L2 aspects and issues in the domain could be given through the message tool and feedback related to awareness for L2L2 could be given by using visualization of landmarks in the breaking news section, reflection tool and message tool. The second is constantly evaluating the way the group members work together. These two directions are supported directly by the Metafora suite of tools and are formative in that they provide learners with information that can help assess and improve their L2L2 process.

Group Reflection on the Social Dimension of Learning As a shared object, a representation of a group learning process constantly evolves and students' shared understanding of the object can be considered as a process of knowing. To make this process of knowing explicit to the group, we identified three distinctive orientations for group reflection, which can be conducted around an online discussion map:

1. Reflecting on individual preferences, collective responsibility and intended level of participation.
2. Reflecting on emerging roles, norms and gaps between individual and collective outcomes.
3. Reflecting on original group learning interpersonal structure and emergent structure, intended individual learning outcomes and achieved outcomes.

These three reflection points are proposed as possible opportunities for learners to think beyond their shared model of group learning process, and emphasize how different types of group regulation and coordination are needed in relation to evolving model.

4 The Web-Based Learning Environment: Metafora

Metafora aims to provide a holistic environment in which students will collaboratively plan and organise their work, as well as collaborate in solving science challenges over a relatively long time period. We present our platform (see Fig. 11.2), which serves both as a toolbox of various learning tools and as communication architecture to support cross-tool interoperability. The toolbox facet of the system provides a graphical container framework in which the diverse learning tools can be launched and used. Basic functionalities that are globally available are the next four: (a) the challenge, (b) the planning and reflection tool, (c) the discussion tool—

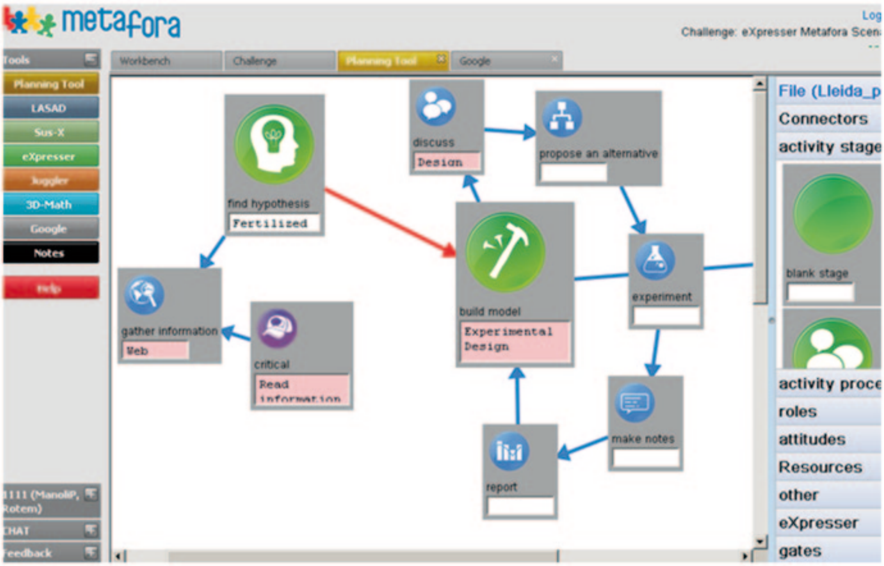


Fig. 11.2 Screenshot of the Metafora platform with several learning tools opened. The planning tool is shown in the centre

Learning to Argue: Generalized Support Across Domains (LASAD) and (d) the microworlds (Sus-X, eXpresser…).

In Fig. 11.2, it can be seen that these four functionalities are clickable for the students on the left-hand side of the screen.

Next, we describe briefly each of these four tools integrated in the Metafora platform:

The Challenge Challenge-based learning methodology was pioneered by the education staff at Apple Inc. and aims to engage learners in meaningful learning context, authentic connection with multiple disciplines, multiple points and multiple possible solutions and focus on the development of twenty-first-century skills (Johnson and Adams 2011).

The Metafora project incorporates challenge-based learning objectives. At the beginning of a typical Metafora-based activity, a group of students is formed and receives a relatively complex assignment—the challenge. The challenge is built in a way that will require the students to plan how they are going to approach the solution in order to reach it on time. After planning, the group begins with an iterative process entailing enactment—discussion—revision of the plan, until the team obtains a solution for the challenge.

The Planning and Reflection Tool The planning/reflection tool offers a visual language that enables students to create and map representations of their work for planning, enacting and reflecting on Metafora learning activities (see the centre of Fig. 11.2). The main feature of this tool is the use of cards and connectors to

Table 11.3 Components and explanation of the visual language

Component	Explanation	Visual example
Activity stage	Key stages of dialogic inquiry-based learning process, e.g. explore, reflect on process	
Activity process	Key activities to concretize the process of each activity stage, e.g. report, anticipate	
Attitude	Key intersubjective orientations to specify the group attitudes during activity stage and process, e.g. critical, ethical	
Role	Key roles to manage and mediate collaboration and cooperation between learners and groups, e.g. manager, evaluator	
Resource	Available resources for activity stages and processes, e.g. group discussion map, microworld artefact, etc.	
Connector	Key relationships between all the components, e.g. causal relationship, temporal relationship	

present a plan for future work or to create a diagram of work completed for reflection. The cards contain visual symbols and titles, as well as space to insert free text (see Fig. 11.2). The symbols and the titles represent different stages and processes related to inquiry learning (e.g. experimentation, hypotheses), attitudes taken towards the group work (e.g. being critical, being open) and cards that allow access to different resources within the Metafora tool box (e.g. the discussion tool called LASAD, microworlds). The connectors represent relational heuristics ("is next", "needed for" and "related to") to explicate how the various cards are related in the given plan. Therefore, the visual language included in the planning and reflection tool has six types of components and they are presented in Table 11.3.

Although it is built as a stand-alone web application, it is most effective as an embedded tool within the Metafora platform, acting as an entry gate and pivot to the other tools. Students can create and modify plans for facing various challenges in math or science. The students can also invoke other tools, including microworlds and discussion tools, and utilize them through specialized resource cards that are part of the visual language.

With the planning tool, students describe how they will tackle their current challenge using the visual language as a guide and then move together through the various planned stages, enacting activities and noting when activities are started and completed. Thus, the plan is also a visual representation of the groups' achievements and current status.

Discussion tools Metafora not only provides discussion tools to allow general communication and collaboration but also aims specifically to support the L2L2 process by allowing discussion and argumentation spaces to integrate artefacts created in other tools. Two discussion tools serve different purposes. First, the chat tool offers a quick and ever-present space for students to gain each other's attention and share informal thoughts in situ. Second, LASAD (Loll et al. 2009) offers a structured approach to discussion through argumentation graphs (see Fig. 11.3), which have been shown to improve discussion and argumentation skills (Scheuer et al. 2010). Both the chat functionality and the LASAD system are customized to display and offer links to referable objects that reside within other tools.

These referable objects are artefacts shared from other tools that not only can be viewed (text or thumbnail images) as components of the discussion but can also be accessed in the context of the original tool through return links. This need emerged from early experimentation with the system and was supported by previous related research (e.g. Stahl 2006).

Figure 11.3 shows a discussion in LASAD in which a referable object from the planning tool has been embedded—experimentation icon. In this LASAD discussion, students are arguing how they are going to design their experiment to test their hypothesis.

Microworlds Various microworlds (Kynigos 2007) which support constructionist learning in mathematical, scientific and socio-environmental domains are also integrated in the Metafora platform. Students, in order to solve specific math and science challenges, might use one of these microworlds.

The research study we present in this chapter has not used any microworld and focuses on the implementation and evaluation of the planning and reflection tool using a visual language representing the key components and features required for L2L2 and for shared scientific inquiry.

5 Objectives and Research Questions

In our research study, we had two main objectives:

1. To understand and specify Metafora's potential affordances to promote the learning and reflection about scientific enquire processes.
2. To study how Metafora's potential affordances may support students' development of L2L2 skills.

This study was conducted as a design-based research (Wang and Hannafin 2005) in which our research questions were the next three:

- RQ1: How does the visual language help students to solve the challenge using key scientific processes?
- RQ2: How does the visual language stimulate discussion and reflection about scientific processes?
- RQ3: Does the visual language help students to develop collaborative learning processes?

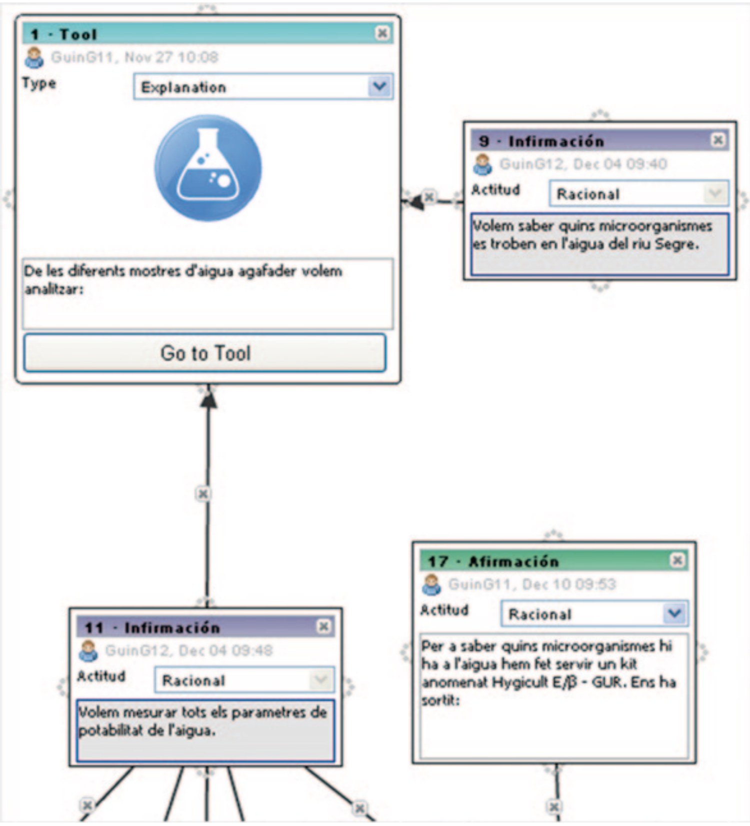


Fig. 11.3 A discussion map in LASAD with embedded referable object—experimentation icon—from the planning tool

6 Method

6.1 Participants

Eleven secondary students of year 11 (16 years old) participated in our study. Students worked in three groups to solve a challenge-based science project. Students worked on the challenge during nine class sessions.

6.2 Procedure

The teacher began introducing the challenge and the visual language to the students. She used the interactive blackboard.

The challenge was:

> The water and environmental European committee has fixed in its normative 2000/60/CE that all European rivers have to be in good ecological conditions in 2015.
> A study of this European committee realized in 2008 found that Segre River (Lleida, Spain) was in good ecological condition only in 75 % of its course. The most polluted section of the river is when the river crossed the town of Lleida.
> What scientific and rigorous proposals could you think about to influence on the society on solving the rivers' problem. Your ideas and actions might be at different levels: authorities, media, society and peers-secondary schools. Write or design a strategy to present your results to the society.

Students were provided with some net resources about: (a) main causes that may pollute the river, (b) ecological good health levels of river and forest and (c) water parameters. These resources were selected by the science teacher. Besides, students could check the Internet.

Afterwards, students planned and solved the challenge using the Metafora planning and reflection tool. The pedagogy used during these sessions was:

- Students worked in small groups during all sessions.
- Work-in-progress presentations and group debate sessions were carried out. Three times during the workshop, every group presented their working progress. In this presentation, students were asked to present not only the work done so far but also the group thinking process: reflect and present their discussions, problems, how they overcame them, use of visual language, collaboration, etc.
- Final group work presentation and whole class discussion were conducted. Every group presented the whole work and the group proposal to influence the society on solving the rivers' problem.

6.3 Data Collection

- The students' group work realized on the computer and students' group discussion during small group work were video–audio recording using a video recorder programme—CAMSTUDIO
- Video-recording sessions of work-in-progress presentation and final presentation
- Video recording of students' dialogue while working together

7 Findings

7.1 How Does the Visual Language Help Students to Solve the Challenge Using Key Scientific Processes?

To answer this research question, we analysed the small group work in the planning tool and their work-in-progress presentations to the whole group class—in which students present what they did, for which purposes, what scientific processes they planned in order to better solve the challenge and the small group worked. All the groups organised their challenge resolution process around the "activity stage" icons which represented a scientific objective to solve the challenge.

Analysing the planning and the icons used by the three groups of students, we observed students took into consideration the next five scientific inquiry stages:

- Define the problem.
- Hypothesis.
- Hypothesis evaluation (methodology—experimental design).
- Discuss findings.
- Draw conclusions and proposals to solve the challenge.

These findings show that the Metafora planning and reflection tool supported students' creation of an inquiry process because students establish the main scientific inquiry stages highlighted in the literature (e.g. Hakkarainen 2010; Shimoda et al. 2002).

Besides, students used the visual cards related to "activity processes" to unpack the processes and actions of the scientific activity stages. The use of the "activity processes" helped students to better define and fulfil the scientific objectives of each activity stages. An example of how students unpack the processes to better define their hypothesis is shown in Fig. 11.4. In this example, students decided to gather new information and evaluated it critically in order to confirm or not their hypothesis.

Furthermore, the analyses of the data showed that "activity processes" icons were mainly used for the next three purposes:

1. Activity processes icons were used as an aid to start thinking in possible actions: brainstorming. An example of this purpose is presented next:
2. Activity processes icons were used as a help to reflect about what they did and consequently plan the next step to solve the challenge. An example of this purpose is presented below:

   Ok, let's see, previous knowledge, and then we observed the data, explored the cartography link and the water agency link, and then we researched for new information.
   …But we don't have enough I think now we have to obtain new data about the river: look at this map [[open a link from the web resources]] it's clickable! It shows the quantity of water of the river at different points. How much water does it have in the different stages of the river? and in Lleida? Look We can compare them.

3. Activity processes icons were used as an aid to organise and structure their actions. Next, we present an excerpt in which can be seen how students discuss about how to reorganise in the planning tool the actions they have already done and from that how students rethink their planning:

Ada: I would put all of this in one block: reflect and analyse. All the information we have in here …Thus, all this information [[pointing at text written in one of the boxes]] is the information we got reading on the web.

Aln: Yes

Ada: I will put the icons reflect and analyse, because we have already analysed it, haven't we?

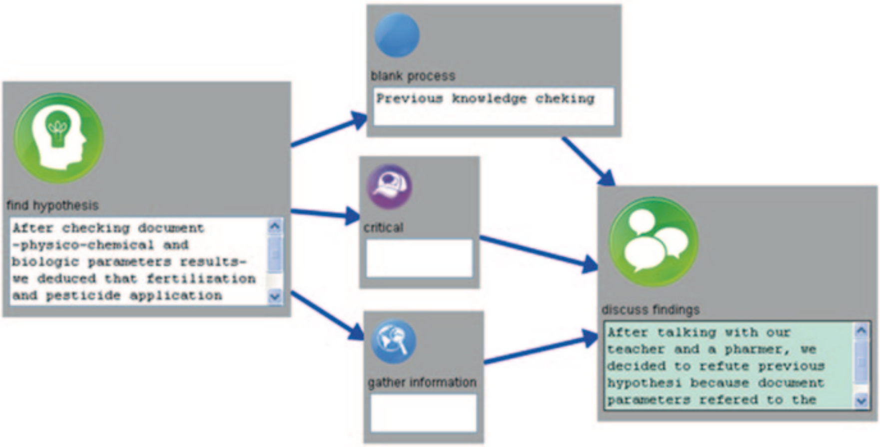


Fig. 11.4 Example of how students unpack the processes to better define the hypothesis

Aln: wait, wait, say it again and I will put the icons
Ada: I try to say what we are doing now?
Aln: Yes, and I agree [[she looks for an icon and drug to the computer screen]]
Ada: Brain storming [[this is the icon that Aln druged]] no, no, this later. We have done is analyses…

The observation of the planning process combined with feedback from students' in-progress presentations suggests that "activity stages" and "activity processes" visual icons promoted students to consider aspects of the scientific research process that they would not have thought otherwise. Therefore, the visual language included in the planning tool enriches students' scientific enquire processes.

7.2 How Does the Visual Language Stimulate Discussion and Reflection About Scientific Processes?

We transcribed and analysed the dialogue of one group of students in one class session. First, we track in the transcription for words related with the visual language. In Fig. 11.5, we compare the number of times students used an icon in the planning tool and the number of times that the inquiry processes are embedded in students' dialogue. During this session, students intensively used the words of the visual language in their discussion. In this line, students used words related with the "activity stages" 30 times but they only put one icon of this category in their planning map. Students used in their discussion words such as: conceptualise the challenge, methodology, predict the results, hypothesis and steps to follow.

In relation to the impact of the visual language icons referred to as "activity processes": students included intensively during their group discussion words related

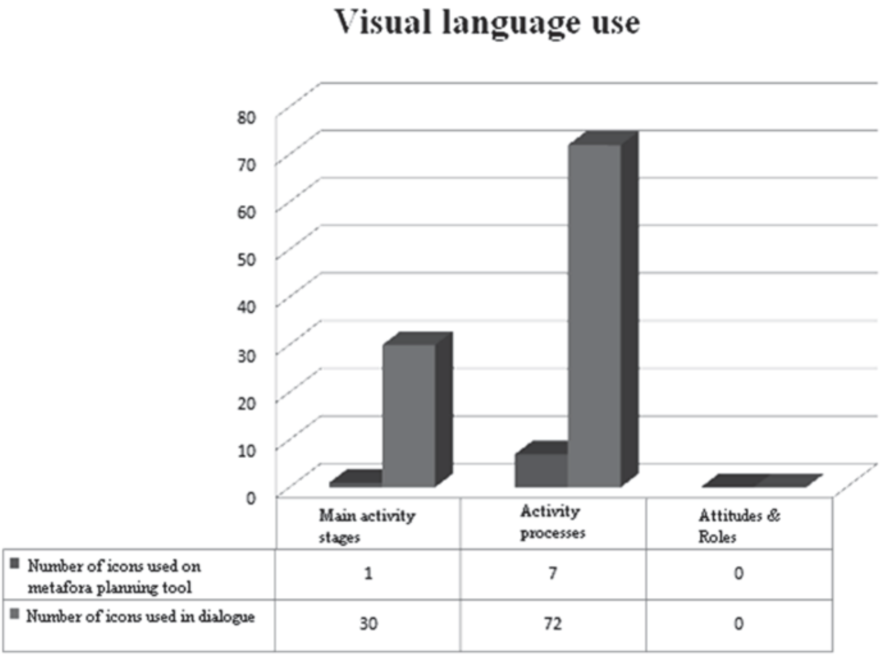


Fig. 11.5 Comparison of used visual language in the planning tool and in students' dialogue

to processes such as: analyse, observe, brainstorm, explore, search for new information, discuss.

From our point of view, this finding is relevant because it might confirm that the visual language had a positive impact on students' dialogue and on the way students organise their science thinking.

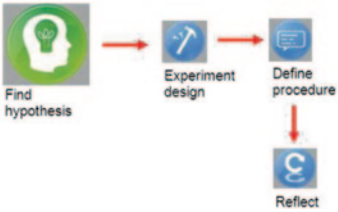
In future research studies, we intend to use "text analysis software" such as "Wordsmith tools" to better analyse the use and the impact of visual language on the learning of scientific inquiry processes.

Additionally, a deeper analysis of students' dialogue showed the presence of students' reflection about the most appropriate scientific processes to carry out in order to solve the science challenge. In Table 11.4, we reproduce an extract of this dialogue and it can be seen how Metafora visual language promoted and mediated the reflection about scientific process to solve the task.

7.3 Does the Visual Language Help Students to Develop Group Learning Processes?

In collaborative learning situations, the process of shared meaning making is seen as just as important as the actual outcome of the activity. In this respect, Mercer and Littleton (2007, p. 25) argue that collaboration involves "a co-ordinated joint com-

Table 11.4 Example of students' dialogue and students' actions in the Metafora planning tool

<table>
<tr><th>Actions in the planning tool—visual language used</th><th>Dialogue</th></tr>
<tr><td>
</td><td>Ada: Let's see. When we do that then?
Aln: So, in theory we are still here. We have not done anything, right? ((laughs))
Ada: Yeh…but from this, we should do an experimental design shouldn't we? Or something.
Aln: If
Ada: This is experimental design, right? [[looking for experimental design icon]]
Aln: Wait, wait, wait. First are the hypothesis
Ada: We need to define what steps we will follow first [[dragging the "define procedure" icon, and observe second
DNLA: If…and reflect as well. Now we are reflecting, aren't we?
Aln: If also
Ada: thinking
Aln: Here and to reflect put an arrow. So, after everything we've done we look in the mirror. Can I do it?… [[requested photocopies of the icons in the DNLA]]
[[Ada recorded in the Metafora and put the last icons in the planning]]</td></tr>
</table>

mitment to a shared goal, reciprocity, mutuality and the continual (re)negotiation of meaning".

A key concept, related to this idea, is the concept of "intersubjectivity", which signifies the process of developing communality in joint activity. Linell (1998, p. 225) argues that, for collaborative projects to be successful and truly collaborative, all parties must be "mutually other-oriented". Additionally, in the context of computer-supported collaborative learning, Wegerif (2007) claimed that it is necessary to develop, through social interaction, a "dialogic space", which he sees as the social realm of the activity within which people can think and act collectively, thus opening up a space between people in which creative thought and reflection can occur.

In this section, we wondered if the Metafora planning and reflection tool stimulated and mediated the development of key L2L2 skills.

The analyses of the session we transcribed showed that students shared meaning making, took reciprocal perspective, were mutually engaged and created a dialogic space in which they thought and acted collectively. Next, we present an excerpt in which collaborative learning processes are explicit.

> Context: Students are analysing different graphics from a web resource about different levels of concentration of nitrites and phosphates in the water of the river in different periods of the year. Ada: tThat's strange…However, I still do not understand why during the watering season there is less [referring nitrites]. Maybe because they are more dissolved. I do not know.

DNLA: I suppose, because it is related with how many times you can water the fields, right?
Ada: Yeh
DNLA: You have to water the fields every 15 days, ok? When you do not have to water is because the humid is high.
Ada: Then, during the watering season, there is less water because the plants absorb it?
DNLA: Yes. Because the land absorb it. They have that.
Ada: Likewise. So the land, during the watering season absorbs water and in the water is where are the phosphates and nitrites, so is logical that there are less… and just when there is no watering… land does not absorb the water and then the water would pass without any difficulty and go to the river again.
Aln: Good explanation, different to my one… but yeh, what you have said is also possible.
DNLA: I know this because my uncle has a field, and I know that he waters every 15 days, and for 4–5 h, they put water in the field till the whole field is watered
Aln: Yeh… it can be, can be
Ada: Yeh, then we can base on this.
Aln: Ok
Ada: With what you are saying DNLA. It is true.
Aln: So if there is no watering, they are not fixed in the land [referring to fertilise] and they go to the river.
Ada: Yes

In this excerpt, Ada and Dnla are mutually engaged in developing arguments to explain what human actions may cause the different levels of nitrites in the water of the river depending on the month of the year. Doing so, Ada and Dnla build their arguments on each other's contributions; both students bring to the discussion different types of arguments and examples, and both students assess each other's arguments in order to build a shared explanation of the scientific phenomena.

Students showed an explicit effort to construct common and shared knowledge which would enable them to come to an agreed and common conclusion. In doing so, students assess and re-elaborate their own and other's ideas and reasons.

8 Conclusions

This chapter discusses the affordances of a new learning environment, supported by new technology that is currently under development: the Metafora system. L2L2 in science is a key complex skill or competence for knowledge age work. The Metafora project aims at developing a better understanding of this complex skill through specifying key features of learning together science processes that students need to be aware of and able to work with, and by embodying these features in a visual language which forms the main component of a planning and reflection tool.

We have reported a design-based research study in which the main objectives were to understand and specify the Metafora's potential affordances in promoting the learning and reflection about scientific inquiry processes and in supporting students' development of L2L2 skills.

Findings suggest that the visual language we have developed can help raise students' awareness of key collaborative scientific inquiry processes. The Metafora visual language helped students to unpack and reflect about the scientific processes to solve a complex science challenge. Additionally, the Metafora visual language promoted students' awareness about aspects and components of their collaborative learning processes in science.

The development of this visual language and its initial successful trials have potential pedagogical significance in science education. In our study, the tool has shown itself to be of value to science teachers who need to teach not only the content of science but also the process of scientific inquiry. Students of our study reported that Metafora helped them to reflect about the nature of scientific methodology and about scientific inquiry processes followed by the group. The Metafora planning tool allows the representation of a shared inquiry process. This representation helped students to better understand the scientific methodology and how to apply it in a specific context.

However, further research is needed to investigate the impact of using this tool on the ability of students to learn together with others in new situations. Our design-based research has explored how the combination of pedagogy promoting talk and collaborative dispositions in students worked together with the visual language tools to stimulate L2L2. Future research could use this evidence to produce a further design framework for an improved implementation of the Metafora system, working closely with teachers to improve the pedagogy to increase the quality and quantity of L2L2. Further research is already planned to explore the potential of the Metafora planning and reflection tool to support distributed individuals learning together via the web.

Acknowledgments This study was funded by EU-R&D project "Metafora—Learning to Learn Together: A visual language for social orchestration of educational activities" (EC/FP7, Grant agreement: 257872) and partially funded by the Ministerio de Ciencia y tecnología of the Spanish government (project number: EDU2012-32415).

References

Anastopoulou, S., Sharples, M., Ainsworth, S., & Crook, C. (2009). Personal enquiry: Linking the cultures of home and school with technology mediated science enquiry. In N. Pachler & J. Seipold (Eds.), *Mobile learning cultures across education, work and leisure*. *Proceedings of the 3rd WLE mobile learning symposium, London, 27th March 2009*. London: WLE Centre.

Brown, A. L., & Campione, J. C. (1996). Guided discovery in a community of learners. In K. McGilly (Ed.), *Classroom lessons: Integrating cognitive theory and classroom practice* (pp. 2292–2370). Cambridge: MIT Press.

Clancey, W. J. (1989). The knowledge level reconsidered: Modeling how systems interact. *Machine Learning, 4*(3/4), 2852–2892.

Crook, C. (1994). *Computers and the collaborative experience of learning*. London: Routledge.

Crow, G., Hausman, C. S., & Scribner, J. P. (2002). Reshaping the principalship. In J. Murphy (Ed.), The educational leadership challenge (pp. 1892–1910). Chicago: University of Chicago Press.

de Jong, T. (2006). Scaffolds for scientific discovery learning. In *Handling complexity in learning environments: Theory and research* (pp. 1071–1128).

De Laat, M. F. (2006). *Networked learning*. Apeldoorn: Politie Academie.

Dewey, J. (1938). *Logic: The theory of enquiry*. New York: Henry Holt.

Grandy, R. E., & Duschl, R. (2007). Role of enquiry in school science. *Science and Education*.

Hakkarainen, K. (2003). Emergence of progressive-enquiry culture in computer-supported collaborative learning. *Learning Environments Research, 6,* 1992–2020.

Hakkarainen, K. (2010). Learning communities in the classroom. International Handbook of Psychology in Education, p. 177.

Hammond, M., & Wiriyapinit, M. (2004). Carrying out research into learning through online discussion: Opportunities and difficulties. In S. Banks, P. Goodyear, C. Jones, V. Lally, D. McConnel, & C. Steeples (Eds.), *Proceedings of the fourth international conference on networked learning 2004* (pp. 4564–4662). Lancaster: Lancaster University.

Hollander, E. P. (1978). *Leadership dynamics: A practical guide to effective relationships*. New York: Free Press.

Johnson, L. F., & Adams, S. (2011). *Challenge-based learning: The report from the implementation project*. Austin: The New Media Consortium.

Keating, C, Robinson, T, & Clemson, B. (1996). Reflective enquiry: A method for organizatinal learning. *The Learning Organization, 3*(4), 354–363.

Kynigos C. (2007). Half-baked logo microworlds as boundary objects in integrated design. *Informatics in Education, 6*(2), 3353–3358.

Kyza, E. A., & Edelson, D. C. (2003). *Reflective enquiry: What it is and how can software scaffolds help*. Paper presented at the annual meeting of the American Educational Research Association. Chicago.

Li, Y., Anderson, R. C., Nguyen-Jahiel, K., Dong, T., Archodidou, A., Kim, I., et al. (2007). Emergent leadership in children's discussion groups. *Cognition and Instruction, 25*(1), 751–811.

Linell, P. (1998). *Approaching dialogue: Talk, interaction and contexts in dialogical perspectives*. Amsterdam: John Benjamins Publishing Co.

Llewellyn, D. (2002). *Inquire within*. Thousand Oaks: Corwin Press.

F. Loll, N. Pinkwart, O. Scheuer, B. M. McLaren (2009). Towards a Flexible Intelligent Tutoring System for Argumentation. In I. Adeo, N. Chen, Kinshuk, D. Sampson, L. Zaitseva, eds., *Proceedings of the 9th IEEE International Conference on Advanced Learning Technologies (ICALT)* (pp. 647–648). Los Alamitos, CA, USA, IEEE Computer Society Press.

Mercer, N., & Littleton, K. (2007). *Dialogue and the development of children's thinking: A sociocultural approach*. London: Routledge.

Roschelle, J., & Greeno, J. (1987). *Mental models in expert physics problem solving, ONR report GK-2, available from school of education*. Berkeley: University of California.

Scharwtz, D., Lin, X., Brophy, S., & Bransford, J. (1999). Toward the development of flexibility adaptive instructional design. In C. Reigeluth (Ed.), *Instructional-design theories and models: A new paradigm of instructional theory* (Vol. II, pp. 1832–1914). Mahwah: Erlbaum.

Scheuer, O., Loll, F., Pinkwart, N., & McLaren, B. (2010). Computer-supported argumentation: A review of the state of the art. *International Journal of Computer-Supported Collaborative Learning, 5*(1), 43–102.

Shimoda, T. A., White, B. Y., & Frederiksen J. R. (2002). Student goal orientation in learning inquiry skills with modifiable software advisors. *Science Education, 86*(2), 2442–2463.

Stahl, G. (2006). *Group cognition: Computer support for building collaborative knowledge (acting with technology)* (Illustrated edition). The MIT Press Massachusetts.

Steed, A., Slater, M., Sadagic, A., Tromp, J., & Bullock, A. (1999). *Leadership and collaboration in virtual environments*. In Proceedings of the IEEE conference on virtual reality (Houston, TX, March).

Thomas, S., & Oldfather, P. (1995). Enhancing student and teacher engagement in literacy learning: A shared enquiry approach. *The Reading Teacher, 49*(3), 1922–2002.

Vonderwell, S. (2003). An examination of asynchronous communication experiences and perspectives of students in an online course: A case study. *Internet and Higher Education, 6,* 779–780.

Wang, F., & Hannafin, M. (2005). Design-based research and technology-enhanced learning environments. *Education, Technology, Research and Development (ETR & D), 53*(4), 10421–10629.

Wegerif, R. (2007). *Dialogic education and technology*. New York: Springer.

Wenger, E. (1998). *Communities of practice: Learning, meaning, and identity*. Cambridge: Cambridge University Press.

Yang, Y., Wegerif, R., Dragon, T., Mavrikis, M., & McLaren, B. (2013). Learning how to learn together (L2L2): Developing tools to support an essential complex competence for the Internet age. In N. Rummel, M. Kapur, M. Nathan, & S. Puntambekar (Eds.), *Proceedings of computer-supported collaborative learning conference*. Madison. International Society of the Learning Sciences (ISLS).

Chapter 12
Learning *in* or *with* Games?

Quality Criteria for Digital Learning Games from the Perspectives of Learning, Emotion, and Motivation Theory

Jan Hense and Heinz Mandl

1 Introduction

Game-based learning (GBL) or learning with digital learning games (DLGs) has been one of the most discussed and propagated forms of media-based learning in recent years. Some programmatic authors (e.g., Gee 2007; Prensky 2007) are extremely optimistic in regard to the potential benefits of GBL, and there is a growing corpus of empirical research on educational uses of DLGs (e.g., Shelton and Wiley 2007; Tobias and Fletcher 2011). However, little effort has been spent until now in systematically analyzing the theoretical underpinnings of learning with digital games (cf. Moreno-Ger et al. 2008).

Our theoretical chapter aims at closing this theory gap in research on DLGs. This task seems particularly important, as at the moment there is little but experiential knowledge on what makes a DLG effective for learning. Methodologically, we analyze learning in conventional digital games from the theoretical perspectives of learning theory, emotion theory, and motivation theory. Undoubtedly, players of conventional digital games often acquire a range of skills and contents while playing, and they do so with immense motivational and emotional involvement. It is assumed that by an analysis of the processes leading to these kinds of implicit learning, the underlying principles can be made explicit and subsequently used for designing effective DLGs. Accordingly, we subsequently deduce criteria and guidelines for the design and application of effective DLGs from the previous theoretical analysis. We conclude with an outlook on possible applications and further challenges for the theoretical foundation of learning with and in DLGs, and a discussion of the role of open access in regard to DLGs.

J. Hense (✉)
Dept. Psychology, Justus-Liebig-Universität Gießen,
Otto-Behagel-Str. 10F, 35394 Gießen, Germany
e-mail: jan.hense@psychol.uni-giessen.de

H. Mandl
Dept. Psychology, Ludwig-Maximilians-Universität München,
Leopoldstr. 13, 80802 München, Germany
e-mail: heinz.mandl@psy.lmu.de

D. G. Sampson et al. (eds.), *Digital Systems for Open Access to Formal and Informal Learning*, 181
DOI 10.1007/978-3-319-02264-2_12, © Springer International Publishing Switzerland 2014

2 The Promise of DLGs

After a period as the "new kid on the block," DLGs have developed into the next "big thing" in the area of media-based education approaches. Similar to earlier trends such as e-learning, many have set enormous expectations in this area. On the one hand, these expectations relate to profitability aspects, as the market for DLGs is believed to have an enormous potential for growth (see Picot et al. 2008). On the other hand, even greater are the expectations of some advocates of digital learning with computers in regard to their potential for educational effects.

Authors such as Gee (2007) or Prensky (2007, 2011) are at the helm of this movement. Their simple, but also persuasive argumentation is as follows: Computer games that originally were only designed for entertainment purposes most often invoke substantial learning processes in players, which vary depending on the nature of the game. For example, action and racing games are expected to increase motor and perception skills, while design and strategy games will increase forward-planning skills, and quest-based adventure games can foster complex problem-solving skills. In addition, depending on the background story and scenario of the game, users may acquire substantial content knowledge about the virtual game world and its mechanics as well. This can occur through the challenging complex tasks of a special force commando team in the context of a tactical "ego shooter," or players may develop a knowledge of history through trade or strategy games with a historic setting. According to the proponents of this line of argumentation, all these learning processes occur without perceiving them as difficult, burdensome, or uncomfortable. On the contrary, digital games are expected to generate an enormous amount of motivation which leads to intensive, sustained, and emotional engagement with the game contents and mechanisms. In fact, this engagement can extend far beyond the reaches of the game, either when users create online communities to exchange information about the game or when they invest substantial effort in developing their own game content in the form of "mods" (modifications).

Advocates of games such as Gee or Prensky also argue that the undeniable potential of digital games to promote unsystematic and implicit learning processes can also be intentionally and directly used to facilitate the acquisition of curricular subject matter. They often refer to showcase model projects such as, to name one example, the program "Revolution" (www.educationarcade.org/node/357), which is based on a modification of the three-dimensional (3D) role-playing game "Neverwinter Nights." Set in the context of the American Revolutionary War, players of "Revolution" are able to experience social situations firsthand in order to develop historical knowledge about this period (see Foreman 2004). In this visually and technically well-developed massively multiplayer online role-playing game (MMORPG), learners are able to take on a variety of roles, e.g., farmer, artisan, or slave, travel freely in an authentic Williamsburg setting, and interact with other human players as well as computer-controlled nonplaying characters (NPCs). In the context of game episodes (chapters), a story thread is generated that enables users to better understand the path to revolution.

As impressive as milestone projects such as “Revolution” and others may seem, the question remains as to whether the principle can truly be applied on a broader scale, such as the proponents of DLGs claim to be the case. Setting aside the question of the resources needed to develop such complex learning games, the main problem concerns didactic quality. For without a doubt, it is not the games themselves that are effective for learning per se. This can easily be demonstrated by drawing on negative examples of expensively designed DLGs which do not necessarily provide an effective learning environment (cf. O’Neil et al. 2005).

3 Learning in Conventional Entertainment Games

In order to answer questions regarding the educational quality of DLGs, we first need to have a better understanding of the learning processes that take place while playing the games (cf. Garris et al. 2002). Our approach is to first analyze games that are intended not for learning but for entertainment purposes, as the idea is to deduct the mechanisms that are effective for learning from conventional digital entertainment games and transfer them to the development of DLGs. In addition, when analyzing computer games from the perspective of theory, it is important not only to look at aspects pertaining to teaching and learning theory but also to consider the motivational and emotional perspectives that play an important role while playing these games (see Bartlett et al. 2009).

3.1 A Learning and Instruction Theory Perspective

The first theoretical perspective used in this analysis is the perspective of learning and instruction sciences. Here, different theoretical approaches can be used to analyze the mechanisms which foster learning in games. The most important seem behaviorism, cognitivism, and individual and social constructivism (Hense and Mandl 2009; Woolfolk 2004). In our context, we do not consider these approaches as mutually exclusive. Instead they should be regarded as complementary, since the learning mechanisms proposed by the different theoretical approaches can be relevant for different learning goals and outcomes. Furthermore, they may be activated to varying degrees in different game types and genres.

Starting with the *behaviorist perspective,* many games teach new skills and contents via operant conditioning with its main principles of positive reinforcement and punishment. Reinforcement in games is often realized by receiving feedback on successfully mastering a sequence of tasks or levels, by collecting some kind of tokens or symbolic currency, or by beating a high score. Punishment, on the other hand, can consist in losing a virtual life, failing a level, losing a position in a race or ranking, or by being defeated by either a human or computer-controlled opponent. These behaviorist principles are most dominant in action, racing, or sport games which need highly developed motor and perception skills with little cognitive processing. Here the players are continually receiving immediate feedback about the success or failure of their actions. Accordingly, behaviorist learning mechanisms can be expected to be most effective in terms of practicing and repeating routines, primarily in the areas of perception and motor skills. Additionally, they are potentially also useful for the acquisition of factual knowledge.

From a *cognitive perspective,* as represented for example by the instructional design approach (e.g., Reigeluth 1983), there are many digital games which present a series of problem-solving activities to players and accordingly can train learners' problem-solving skills in different content domains. This generally occurs when the players use the information that is embedded either within the game context or the game scenario to solve more or less complex cognitive problems. Games that operate on this principle contain a strong narrative component and players often have to consider various potential solutions and select alternative paths prudently. Adventure and role-playing games are classical applications for these principles. In addition to helping players build problem-solving skills, these kinds of games can also be used to foster knowledge acquisition and increase comprehension. This is accomplished by providing information within the narrative of the game, which needs to be applied to the solution of a given problem.

From an *individual–constructivist perspective* (e.g., Brown et al. 1989; Resnick 1989), games may be regarded as providing a rich, authentic, and immersing environment for self-directed, discovery-, inquiry-, or problem-based learning activities. The prerequisites for this are challenging tasks or problems that players regard as authentic and relevant, either in relation to the virtual reality of the game that they can to relate to or in relation to their own experiences. Based on such problems, the game forces players to analyze the situation, hypothesize on the underlying system mechanics, and to test out a variety of solutions, as well as gain experience with and reflect on a specific subject area or phenomenon. Examples of this are strategy and design games, since they are more or less based on simulations of aspects from the real world that serve as a context for the specific activities.

From the *perspective of social constructivism* (e.g., Bielaczyc and Collins 1999), finally, the focus shifts to the social and cooperative aspects of computer games. Learning in the context of computer games can here be interpreted as the joint construction of socially shared knowledge, as this has been traditionally examined through research on learning communities or on collective information processing. Such processes can be often observed in the context of MMORPGs. Here, players virtually come together in teams with clearly defined roles in order to master tasks when the solution requires a high degree of common planning and coordinated effort. The players communicate and cooperate with each other not only in the context of the game, but also often via community elements such as online forums, chats, or instant messaging which allows players to coordinate and exchange ideas.

3.2 An Emotion Theory Perspective

The influence of emotions on the learning process has often been neglected to date in educational research (see Astleitner 2000). Especially in the context of learning in computer games, it is important that emotions be taken into consideration as well. Even if the research to date has been relatively sparse, it can be said with a degree of certainty that positive emotions such as joy or satisfaction generally have a positive influence on effective learning (Pekrun 1992). With respect to negative emotions, it is important to distinguish between deactivating negative emotions such as boredom or hopelessness and activating negative emotions such as fear or anger. While it can be assumed that deactivating emotions generally do not support learning processes, the influence of activating negative emotions is more complex. If these are present in the right amount, they can have an activating effect, but if they are excessive, they can have a blocking effect (see Rheinberg 1999). Even when there is the right amount of an activating negative emotion, it is wise to use caution because the motivational effect of negative emotions such as fear or anger is extrinsic and may actually detract from the actual subject matter and learning process.

Fun and joy are the two things that first come to mind when examining individual emotions more closely in relation to computer games. If one tries to identify exactly what makes a player experience fun and joy, you will hear many different answers (see Choi et al. 1999). Reasons may include aesthetics such as graphics, animation, music, and sound effects or aspects of the game's narrative. In addition, games often provide players with the opportunity to immerse into a virtual world or to take on an artificial identity and to experience the joy of success and other social aspects of the game. It is also important that the joy of playing the game is not diminished by too low or too high a difficulty level, through subjective unfairness, or due to usability issues. In addition to fun and joy, there are also other positive emotions such as curiosity, satisfaction, and pride that can also be beneficial to learning processes.

With respect to negative emotions, it goes without saying that computer games aim to minimize deactivating emotions such as boredom or hopelessness. Activating negative emotions, on the other hand, are often specifically promoted. A certain amount of frustration when the goals of a game cannot be achieved on the first try is a prerequisite to motivate players to try a second time. Fear can also play an important role in certain game genres such as ego shooters, especially when it plays a part in horror scenarios. However, this also highlights the ambiguities pertaining to negative emotions because there are certain mechanisms that would not be suitable to be used for processes intended to promote learning. When considering the use of computer games for learning purposes, it seems safe to conclude that it makes sense to maximize positive emotions and to generally avoid negative emotions.

When analyzing the design of successful computer games from the perspective of emotion psychology, it becomes clear that these games generally succeed when they adhere to the principles discussed above. Examples of techniques that can be used for this purpose are state-of-the-art design, an adaptive level of difficulty, target group-specific virtual worlds and plots, immersing narratives, and intuitive operation. It is also important to note that failing to meet one of these aspects may not prevent a game from being successful. This indicates that the different aspects that affect emotion psychology may compensate for one another to a certain degree. Therefore, the individual and varied preferences of the players play an important role and should be given due consideration.

3.3 A Motivation Theory Perspective

The final important theoretical perspective for analyzing learning processes in computer games is motivation theory. There are a number of approaches that can be drawn on to understand why computer games often are so attractive and motivating for players. The most relevant are constructs such as achievement motivation, social motivation, self-efficacy, interest, and flow (Urhahne 2008). Of particular interest is the self-determination theory of motivation (Deci and Ryan 2000), which integrates certain elements of some of the other approaches mentioned. It concentrates on explaining intrinsic motivation which is especially effective for learning because it is not fueled by external rewards, but is rather directed at the specific activity itself. In the context of learning in computer games, it makes sense to examine this approach more closely.

Self-determination theory postulates that intrinsic motivation depends on fulfilling three basic psychological needs: competence, autonomy, and relatedness. *Competence* relates to the construct of self-efficacy and describes the experience when an individual is in a position to be in control and master a situation. There is no doubt that this is one of the most important and most attractive characteristics of well-designed computer games (cf. Salen and Zimmerman 2004) since they continuously enable players to experience self-efficacy. It is also interesting to note that this often occurs through contexts that users often do not have access to in real life, such as driving race cars in a racing game, governing a city in a design simulation, or fighting dragons in a 3D role-play, a fact which refers to the role of interest in this context (see below).

In the context of the self-determination theory, *autonomy* describes the ability to strive towards one's own goals, interests, and aptitudes free from outside influences. While some computer games have a linear structure, most offer certain degrees of freedom in specific aspects. Examples for a high level of autonomy in computer games can be found in the aforementioned MMORPGs or in other games adhering to the "open world" concept. Their main appeal is that they provide a simulated reality and allow players to develop their character and its behavior in the direction of their choosing. In these cases, there is often no concrete goal or end to the game. Of course, there are limitations to this autonomy through the rules of the simulation and its limitations. The game's designers' task therefore is to offer enough degrees of freedom and incentives to stimulate players' exploration.

The third important prerequisite for motivating behavior postulated by the self-determination theory is *relatedness*. This can be defined as the feeling of belonging to a social community, whether it be with like-minded individuals, peers, or colleagues. In this regard, the social elements that are part of modern multiplayer games have enormous potential. Even outside of the game itself, this can be observed in the many online communities that are formed around popular games. It is also interesting to note that feelings of relatedness can also develop with virtual characters. This could be with virtual family members in simulations such as the popular "Sims" series, or computer-controlled "Party" members in adventure or conflict-oriented games that use the help of film-like interim scenes to breathe life into the individual characters.

Two other important motivational constructs beyond self-determination theory should be mentioned as particularly important in regard to games, namely interest and flow. *Interest* can be defined as the special relation between a person and a specific content domain or area of knowledge (Krapp 2005). In regard to games, the motivational potential of interest is relevant, as it highlights the role of game genre and narrative. Both are important criteria for a game's success among different groups of players, and it is important to note that players of entertainment games are usually free to follow their specific interest in choosing a game.

A final construct to be mentioned here is *flow* (Csikszentmihalyi 1975). Flow denotes an "optimal state" of motivated action, in which a person is fully immersed in a challenging task or activity while being skilled enough to master this task or activity. As cognition and affection both are entirely concentrated on the activity, flow allows a maximum level of performance. To induce flow, a task or activity has to meet a number of conditions: It has to have clear goals, the learner's subjective skills have to match with the task's level of challenge, and immediate and informative feedback has to be provided. As good game design is careful to meet these conditions, e.g., by successively and implicitly teaching players the skills needed in a game, flow can be considered a potent element of players' motivation

4 Quality Criteria for DLGs

What conclusions can be drawn from our analysis of educational, emotion, and motivation theories of learning in computer games? If one agrees with the argument that DLGs can make use of the mechanisms that are used in conventional entertainment games in order to support intended learning processes (cf. Linehan et al. 2011), then it should be possible to use the results of our analysis to derive theoretically well-supported quality criteria for DLGs. On the basis of these considerations, we have developed a list of theoretically grounded quality criteria for DLGs (Table 12.1).

In the recent past, we have used this list of criteria in a number of practice-related projects, which were either concerned with supporting the conceptual design phase of DLGs, with quality analyses of early versions of DLGs, or with the formative evaluation of nearly finished games. Some important experiences have come from these applications. The most important observation was that the full educational

Table 12.1 Quality criteria for the design, quality analysis, and evaluation of DLGs

1. Clearly define the learning goals of the game without neglecting the playful elements
2. Make use of the full spectrum of learning principles used in digital games
   (a) Behaviorist principles
   - Provide direct feedback (particularly reinforcement) on learners' actions
   - Give opportunities for exercise and practice

   (b) Cognitivistic principles
   - Embed complex problems within the game context
   - Embed information needed to solve the problems within the game context and narrative

   (c) Constructivist principles
   - Create realistic problems which are authentic and personally relevant to the players
   - Offer different perspectives and contexts for a given content
   - Create a social context for learning
   - Provide instructional support
   - Offer opportunities for learners' own construction processes
3. Evoke positive emotions
   (a) Guarantee that learners have fun, e.g.,
   - Provide an attractive game design
   - Maximize usability
   - Avoid frustration and disappointment

   (b) Provoke learners' curiosity, e.g.,
   - Offer different choices
   - Offer opportunities for exploration

   (c) Allow for satisfaction and pride
   - Provide positive feedback for learners' accomplishments
   - Create opportunities for presentation of learners' accomplishments
   - Do not let learners fail (too often)
4. Evoke and keep up motivation
   (a) Foster intrinsic motivation
   - Make learning and playing intrinsically attractive
   - Avoid too much focus on extrinsic rewards (score, awards, etc.)

   (b) Allow for feelings of competence
   - Set goals which are challenging yet realistic given the learners' ability
   - Give learners complete control over their success (reduce influence of chance)
   - Ensure frequent and constant opportunities for feeling competent

   (c) Provide autonomy
   - Provide freedom choice, but avoid too much uncertainty about possible negative consequences
   - Provide freedom of action

   (d) Enable social relatedness
   - Provide in-game cooperation with real and/or virtual partners
   - Create game-related communities of learners

   (e) Meet learners' interests
   - Tailor game subject, narrative, and genre to learners' interests
   - Offer choices for the different interests of different learners

   (f) Enable flow
   - Clearly state learners' goals at each stage of the game
   - Adapt difficulty level to learners' ability and skills
   - Provide constant, immediate, and informative feedback

Note: For the sake of applicability, the criteria here are presented in the form of recommendations potential of computer games, as indicated in our list of criteria, is often used only to a little degree. On the surface, it is often immediately apparent that many DLGs cannot keep up technically with commercial games due to their smaller budgets. However, as already indicated, a simpler design may not necessarily prevent a (learning) game from being successful, as can be seen in the growing market of casual games and mobile phone games. Far more important than technological inferiority, however, would be inferiority relating to educational aspects that can be identified using the criteria list. Three problems seem common to many DLGs.

Firstly, it is sometimes the case that unsuitable learning mechanisms are used for the wrong learning goals and contents. Behaviorist learning through reinforcement has its place, but more when it is important for learners to practice and repeat facts rather than when learners must learn new information or when the goal is to reach a more in-depth understanding of the subject matter. So it is important to provide for a close match of learning goal and learning mechanism in each specific case.

Secondly, it is often the case that the wide range of possible cognitive, emotional, and motivational mechanisms to promote learning are not utilized and combined in meaningful ways. Instead, there is often a one-sided focus on individual aspects such as attractive design, frequent incentives, or a strong narrative element. However, a good design does not compensate for a less attractive game or learning mechanisms. Frequent incentives lose their motivating power when they are too easy to achieve. And a strong narrative element is only captivating when the players have enough opportunities to interact within the virtual world. So care has to be taken in cautiously balancing the spectrum of possible learning mechanisms.

Thirdly, and herein seems to lie the biggest challenge, it is always important that game play and learning are synthesized in a meaningful way. Our experience has shown that some products announced as DLGs are in fact mere e-learning programs to which a number of game elements have been added. Although there is a game-like aspect to these programs, the actual contents might still be transmitted through slide presentations or spoken instructional passages, the difference being that these elements have been more or less cleverly embedded within a game context.

5 Applications and Significance

Our theoretical analyses demonstrate that digital games in fact can have a lot of inherent potential to foster learning via a number of theoretically well-established cognitive, emotional, and motivational mechanisms. At the same time, it is evident that, given the state of the art of DLGs, many applications still fall short of making use of the full range of mechanisms and often only realize the most basic promoting functions, such as positive reinforcement. Accordingly, the results of the above theoretical analysis can be used to derive a systemized list of criteria and guidelines for designing effective DLGs.

The educational significance of this chapter is twofold. For the practice of designing and applying DLGs in educational contexts, it gives guidance on what criteria need to be met to make them effective learning environments. For further research, it provides a general framework which can be applied for the empirical analysis of learning with DLGs.

Until today, the fact that computer games can provide influential learning environments had mostly been considered in the context of research conducted on the effects of media. In the past, this research focused primarily on the effects of violent contents and has brought forth evidence how these can have short- and long-term effects on the experiences and behaviors of regular players (see Barlett et al. 2009). Despite these negative aspects, we do not see any reason that the learning potential of computer games cannot be used in a positive sense for productive learning processes.

The accompanying challenges can be seen in the challenges presented in this chapter that many DLGs have been struggling with to this day. At the core of all of these difficulties is a basic issue relating to the hypothesis that the advantages of entertainment computer games can be easily transferred to DLGs. The basic problem lies in the fact that learning *in* computer games is something different from learning *with* computer games. Our core hypothesis can therefore only be fulfilled if it is possible to truly synthesize intended learning processes with game processes.

However, we see positive opportunities for the effective use of DLGs when central principles of educational psychology are considered, as we have summarized in our criteria list. It would be a mistake to rely too heavily upon the learning effectiveness of the medium of the computer game alone. The risk is that we would again take a promising approach with a lot of potential to effectively promote learning processes and ruin it by deficits in the aspects relating to educational theory. This would lead to great disillusionment, as has been the case with e-learning before.

6 DLGs and the Agenda of Open Access

In conclusion, we turn our attention to the question how DLGs and their quality relate to the agenda of open access. Open access has originally been closely associated with free and public access to scientific research results and publications (Laakso et al. 2011). In recent years, the focus of the discussion has become broader, incorporating questions of access to formal and informal learning environments.

Although different rationales can be given for the open access agenda, most arguments are either normative or instrumental. The normative rationale holds that knowledge resources should generally be made publicly, i.e., without access restrictions, available, in particular if these resources have been generated with the support of public funding. The instrumental rationale, on the other hand, contends that the broader the access to knowledge and learning resources, the greater use will be made of these resources. Research on open access publishing in fact indicates that this instrumental expectation is often fulfilled, although the quality of the research seems to be a key influence on increased citations (Antelman 2004; Hajjem et al. 2005; McCabe and Snyer 2013).

Turning to DLGs, which genuinely are software products, it seems important to differentiate between three related yet differing concepts, *open access, open content,* and *open source*. One obvious difference between these concepts is the object it is conventionally attached to, with open source relating to software, open access to scientific research, and open content to other forms of media content (Mantz 2007). Due to these different contents, different emphases of the three concepts can be explained:

- A main concern of *open access,* which is less prevalent in the other concepts, is permanence of access. The scientific discourse depends on even outdated knowledge remaining accessible and referable, while computer software and others may lose their intrinsic value over time and remain relevant only out of historical interest.
- An important issue which is specific for *open content* is the question of copyright licensing. To regulate what rights users of open content are granted, e.g., for using, modifying, and redistributing contents, sophisticated systems have been devised (e.g., creativecommons.org).
- *Open source,* finally, has a unique history of collaborative development of software products. Openness here is a necessity to enable the joint efforts of volunteers, which has succeeded in the past to bring forth impressive products as an alternative to commercial close source programs.

Given these different emphases, it seems that in the context of DLGs not only the concept of open access seems relevant but also that all three perspectives need to be considered.

Open access with its emphasis on permanence of access is important in particular if scientific research is being conducted on and with DLGs. As the reproducibility of findings is a basic criterion for sound research, it seems problematic if due to today's brief hardware and software innovation cycles a DLG stops working after relatively brief periods of time, as can often be demonstrated by trying to run DLGs not much older than around 5 years.

From an open content perspective, it is noteworthy to examine the kinds of licenses DLGs are being distributed under. While DLGs can be made available commercially as well as for free, their developers usually do not enable users to actively modify and redistribute them. However, this might be one possible way to increase their long-term dissemination and impact, while at the same time offering routes to avoid a quick degradation due to the aforementioned brief innovation cycles. An excellent and scientifically evaluated DLG like Re-Mission, which has started to look aged after only a few years, could potentially prolong its life cycle if it would not have been distributed as a closed-source product, which leads to the final perspective.

Thus, it seems that the most potent perspective for DLGs can be found in the open source movement. Distributing software as freely as source code is a practice which dates back to the early phases of the computer history, when it used to be the primary way of disseminating software before the emergence of commercial software markets (Raymond 1999). Accordingly, it has a much longer tradition than the open access and open content movements, and has long proven its potential to bring forth products which easily rival their commercial counterparts concerning quality as well as popularity among users. So a strong argument can be made that distributing DLGs as a free and open software might be the most effective overarching strategy to increase their impact as learning environments.

References

Antelman, K. (2004). Do open-access articles have a greater research impact? *College & Research Libraries, 65*(5), 372–382.

Astleitner, H. (2000). Designing emotionally sound instruction. The FEASP-approach. *Instructional Science, 28,* 169–198.

Barlett, C. P., Anderson, C. A., & Swing, E. L. (2009). Video game effects-confirmed, suspected, and speculative: A review of the evidence. *Simulation & Gaming, 40*(3), 377–403.

Bielaczyc, K., & Collins, A. M. (1999). Learning communities in classrooms: A reconceptualization of educational practice. In C. M. Reigeluth (Ed.), *Instructional design theories and models. Vol. II: A new paradigm of instructional theory* (pp. 269–292). Mahwah: Erlbaum.

Brown, J. S., Collins, A., & Duguid, S. (1989). Situated cognition and the culture of learning. *Educational Researcher, 18*(1), 32–42.

Choi, D., Kim, H., & Kim, J. (1999). Toward the construction of fun computer games: Differences in the views of developers and players. *Personal Technologies, 3*(3), 92–104.

Csikszentmihalyi, M. (1975). *Beyond boredom and anxiety*. San Francisco: Jossey-Bass.

Deci, E. L., & Ryan, R. M. (2000). The "what" and "why" of goal pursuits: Human needs and the self-determination of behavior. *Psychological Inquiry, 11,* 227–268.

Foreman, J. (2004). Video game studies and the emerging instructional revolution. *Innovate, 1*(1). http://www.innovateonline.info/index.php?view=article & id=2. Accessed 12 May 2009.

Garris, R., Ahlers, R., & Driskell, J. E. (2002). Games, motivation, and learning. A research and practice model. *Simulation & Gaming, 33,* 441–467.

Gee, J. P. (2007). *Good video games + good learning. Collected essays on video games, learning and literacy*. New York: Peter Lang Publishing.

Hajjem, C., Harnad, S., & Gingras, Y. (2005). Ten-year cross-disciplinary comparison of the growth of open access and how it increases research citation impact. *IEEE Data Engineering Bulletin, 28*(4), 39–47.

Hense, J., & Mandl, H. (2009). Bildung im Zeitalter digitaler Medien—Zur wechselseitigen Verflechtung von Bildung und Technologien (Education in the age of digital media. On the reciprocal interrelation of education and technology). In M. Henninger & H. Mandl (Eds.), *Handbuch Medien- und Bildungsmanagement (Handbook of media and education management)* (pp. 21–40). Weinheim: Beltz.

Krapp, A. (2005). Basic needs and the development of interest and intrinsic motivational orientations. *Learning and Instruction, 15,* 381–395.

Laakso, M., Welling, P., Bukvova, H., Nyman, L., Björk, B.-C., Hedlund, T., et al. (2011). The development of open access journal publishing from 1993 to 2009. *PLoS ONE, 6*(6), e20961.

Linehan, C., Kirman, B., Lawson, S., & Chan, G. (2011). *Practical, appropriate, empirically-validated guidelines for designing educational games*. Proceedings of the 2011 annual conference on human factors in computing systems—CHI '11. New York, NY, USA, pp. 1979–1988.

Mantz, R. (2007). Open source, open content und open access. Gemeinsamkeiten und Unterschiede (Open source, open content and open access, commonalities and differences). In B. Lutterbeck, M. Bärwolff, & R. Gehring (Eds.), *Open Source Jahrbuch 2007. Zwischen freier Software und Gesellschaftsmodell (Open Source Yearbook 2007. Between free software and society model)* (pp. 413–426). Berlin: Lehmanns Media. (http://www.opensourcejahrbuch.de/download/jb2007/ osjb2007-06-03-mantz.pdf).

McCabe, M. J., & Snyder, C. M. (2013). *The rich get richer and the poor get poorer: The effect of open access on cites to science journals across the quality spectrum*. Available at SSRN: http://ssrn.com/abstract=2269040, http://dx.doi.org/10.2139/ssrn.2269040. Accessed 24 Feb. 2014.

Moreno-Ger, P., Burgos, D., Martínez-Ortiz, I., Sierra, J. L., & Fernández-Manjón, B. (2008). Educational game design for online education. *Computers in Human Behavior, 24,* 2530–2540.

O'Neil, H. F., Wainess, R., & Baker, E. L. (2005). Classification of learning outcomes: Evidence from the computer games literature. *The Curriculum Journal, 16,* 455–474.

Pekrun, R. (1992). The impact of emotions on learning and achievement. Towards a theory of cognitive/motivational mediators. *Applied Psychology*: *An International Review, 41,* 359–376.

Picot, A., Zahedani, S., & Ziemer, A. (Eds.). (2008). *Spielend die Zukunft gewinnen. Wachstumsmarkt Elektronische Spiele [Playfully winning the future. The growing market of electronic games]*. Berlin: Springer.

Prensky, M. (2007). *Digital game-based learning*. St. Paul: Paragon House Publishers.

Prensky, M. (2011). Comments on research comparing games to other instructional methods. In S. Tobias & J. D. Fletcher (Eds.), *Computer games and instruction* (pp. 251–278). Albany: State University of New York.

Raymond, E. S. (1999). *The cathedral & the bazaar. Musings on linux and open source by an accidental revolutionary*. Cambridge: O'Reilly.

Reigeluth, C. M. (1983). Instructional design: What is it and why is it? In C. M. Reigeluth (Ed.), *Instructional theories and models: An overview of their current status* (pp. 3–36). Hillsdale: Erlbaum.

Resnick, L. B. (Ed.). (1989). *Knowing, learning, and instruction: Essays in honor of Robert Glaser*. Hillsdale: Erlbaum.

Rheinberg, F. (1999). Motivation und Emotion im Lernprozess. Aktuelle Befunde und Forschungsperspektiven (Motivation and emotion in learning processes. Current research results and perspectives). In M. Jerusalem & R. Pekrun (Eds.), *Emotion, Motivation und Leistung (Emotion, motivation and performance)* (pp. 189–204). Göttingen: Hogrefe.

Salen, K., & Zimmerman, E. (2004). *Rules of play: Game design fundamentals*. Cambridge: MIT Press.

Shelton, B. E., & Wiley, D. (Eds.). (2007). *The educational design and use of simulation computer games*. Rotterdam: Sense Publishers.

Tobias, S., & Fletcher, J. D. (Eds.). (2011). *Computer games and instruction*. Albany: State University of New York.

Urhahne, D. (2008). Sieben Arten der Lernmotivation. Ein Überblick über zentrale Forschungskonzepte (Seven kinds of learning motivation. A review of current research perpectives). *Psychologische Rundschau, 59,* 150–166.

Woolfolk, A. (2004). *Educational psychology*. Boston: Pearson.

Chapter 13
Digital Game-Based Learning in the Context of School Entrepreneurship Education: Proposing a Framework for Evaluating the Effectiveness of Digital Games

Hercules Panoutsopoulos and Demetrios G. Sampson

1 Introduction

In the past few years, we have witnessed radical technological advancements with unprecedented effects on our personal, social, and professional lives. By providing unique affordances for accessing, creating, editing, and sharing digital content, available tools and services have dramatically changed the ways in which people communicate, conduct transactions with institutions and organizations, become informed, and learn (JISC 2012). Continuously evolving technologies have significantly affected most aspects of everyday life, ranging from leisure activities to adopted practices and conditions at the workplace, and thus, have completely transformed the knowledge that needs to be acquired and the skills that need to be developed in today's societies (UNESCO 2005).

Given the emerging societal and professional development needs, it is imperative that a paradigm shift from traditional knowledge-based education to competence-based education takes place (Sampson and Fytros 2008, p. 157). To this end, the Commission of the European Communities (2005) has proposed a competence framework for lifelong learning, targeted at policy makers, education providers, employers, and learners themselves, with entrepreneurship being one of the eight key competences for "*personal fulfillment, social inclusion, active citizenship and employment*" (p. 3).

H. Panoutsopoulos (✉)
Doukas School Greece, 151 Mesogeion Street, 151 26 Athens, Greece
e-mail: herculespanoutsopoulos@gmail.com

D. G. Sampson
Department of Digital Systems, University of Piraeus,
150 Androutsou Odyssea Street, GR-18532 Piraeus, Greece
e-mail: sampson@unipi.gr

Information Technologies Institute, Centre for Research and Technology—Hellas,
Thessaloniki, Greece
e-mail: sampson@iti.gr

D. G. Sampson et al. (eds.), *Digital Systems for Open Access to Formal and Informal Learning,*
DOI 10.1007/978-3-319-02264-2_13,

Entrepreneurship, defined as "*an individual's ability to turn ideas into action*" by mobilizing "*creativity, innovation and risk taking, as well as the ability to plan and manage projects in order to achieve objectives*" (Commission of the European Communities 2005, p. 18), constitutes a significant indicator of the economic and cultural growth of societies, and hence, the development of an entrepreneurial culture receives increased attention. School-based education can significantly contribute toward this direction, starting from young people, since attitudes, perceptions, and skills begin to develop from an early age (Commission of the European Communities 2006).

Digital games, and especially business simulation games, constitute a technological medium that has the potential to facilitate entrepreneurship education initiatives at the school level. By allowing for the adoption of virtual identities, exploration of the virtual world of the game, interaction with virtual objects, investigation of cause and effect relations, searching for information, and making decisions (Gee 2007; Kim et al. 2009), digital games engage their users in active experimentations and facilitate learning through the application of trial-and-error approaches within virtual spaces where performed actions have no real-life consequences (Dumbleton and Kirriemuir 2006, pp. 233–240; Kirriemuir and McFarlane 2004; Whitton 2010, pp. 22–32).

Within this context, the aim of this book chapter is to (a) analytically describe the role that digital games can play as tools capable of enhancing entrepreneurship education (with a specific focus on school entrepreneurship education and its particularities) and (b) propose a framework for evaluating the effectiveness of digital games in this domain of application. To this end, after outlining general goals and objectives of entrepreneurship education, documenting the potential of digital game-based learning, and providing insights into existing practices regarding the evaluation of entrepreneurship education, we proceed to a review of literature with respect to the outcomes of game-supported interventions, as well as attempts to propose game-based learning evaluation frameworks specifically targeted at entrepreneurship education. After that, we continue with the presentation of our proposed evaluation framework based on existing game-based learning evaluation frameworks and affordances of business simulation games. Conclusions and implications for further research are presented as part of the discussion section of the book chapter.

2 Theoretical Background

2.1 Entrepreneurship-Related Goals and Objectives at Different Levels of Education

According to the European Commission's "'Best Procedure' Project on Education and Training for Entrepreneurship" report (2002), "*teaching and learning about entrepreneurship involve developing knowledge, skills, attitudes, and personal qualities appropriate to the age and development of pupils or students*" (p. 15). Entre-

Table 13.1 Personal qualities that need to be developed as part of provided entrepreneurship education and their descriptions. (European Commission 2002)

Personal qualities	Description
Aspects of management competence	Ability to *solve problems* with an emphasis on abilities that relate to *planning, decision making, communicating,* and *assuming responsibility*
Aspects of social competence	Ability to *cooperate, network,* and *assume new roles*
Personal fields of competence	Develop *self-confidence* and *motivation* to perform, learn to *think critically* and *independently,* willingness and ability to *learn autonomously*
Entrepreneurial qualities	Exhibit *personal initiative, proactivity,* and *creativity*. Being prepared to *confront risks*. *Implement ideas*

Table 13.2 Alignment between different levels of education and learning objectives intended to be achieved as part of entrepreneurship education. (European Commission 2002)

Level of education	Intended learning objectives
Primary education	Fostering *personal qualities* such as creativity, spirit of initiative, and independence. Development of an *entrepreneurial attitude*
	Knowledge of the world of business. *Understanding* the role of entrepreneurs and enterprises
Secondary education	Fostering *personal qualities* such as *creativity, spirit of initiative,* and *independence*. *Raising awareness* of students about self-employment
Tertiary education	Developing skills associated with methods of *identifying* and *assessing* business opportunities Developing the *capacity to draft* real business plans

preneurship education should not confine to the acquisition of core knowledge but needs to adopt a broader perspective by focusing on the achievement of goals and objectives related to a range of relevant skills, attitudes, and personality traits. For example, as made evident from the above definition, teaching and learning about entrepreneurship should target the development of "*personal qualities,*" which as presented with the help of Table 13.1, consist of a number of skills, characteristics, and behaviors that the individual should possess and be able to exercise (European Commission 2002).

However, learner characteristics, depending on age and developmental stage, have implications for the definition of entrepreneurship-related goals and objectives that could be achieved at different levels of education. As shown in Table 13.2, the European Commission (2002) has proposed an alignment between different levels of education and learning objectives to be achieved as part of entrepreneurship education programs.

A more thorough analysis of entrepreneurial skills and attributes, which can be developed at the secondary level of education and are grouped into three distinct categories (namely "*generic or personal attributes,*" "*generic or personal skills,*" and "*business skills*"), is provided by the European Commission's "Best Procedure Project: 'Mini-Companies in Secondary Education'" report (2005). To better illustrate the above-described categorization, we may refer to (a) problem solving, critical thinking, and team working as skill examples falling into the "*generic* *or personal skills*" category; (b) involvement in market research, development of business plans, and product advertising as skill examples falling into the "*business skills*" category; and (c) self-confidence, exercising autonomy, and taking initiatives as examples for "*generic or personal attributes.*"

Similarly, the Organization for Economic Co-operation and Development (OECD 2009) describes three types of entrepreneurship education programs, which can be delivered at various levels of education, targeted at the attainment of different sets of learning objectives labeled as "*acquisition of core skills,*" "*development of personal and social skills,*" and "*skills related to business start-up*" or "*financial literacy.*"

In an attempt to summarize existing definitions of entrepreneurship-related goals and objectives, intended to be achieved at different levels of education, we conclude that school entrepreneurship education mostly emphasizes the development of attitudes and skills (with more emphasis being posed on generic skills rather than skills related to business start-up and management), with the acquisition of factual knowledge being a side effect of participation in learning activities. Such learning activities may involve the development of projects, learning by playing, and presentation of case studies (European Commission 2002). By considering the focus of school entrepreneurship education on skills and attitudes development, it is our intention to proceed to an analysis of digital games' role as tools for supporting the achievement of entrepreneurship-related goals and objectives.

2.2 Digital Game-Based Learning as a Means for Supporting School Entrepreneurship Education

Digital game-based learning is a research field within the wider context of technology-enhanced learning that has attracted, during the past few years, the attention of both the research and educational community (Kirriemuir and McFarlane 2004; Sandford and Williamson 2005; Van Eck 2007; Chen and Chan 2010). In their definition of the term digital game-based learning, Tang et al. (2009) emphasize the capacity of digital games to support any learning process and the necessary assessment and thus, define digital game-based learning as "*the use of computer games that possess educational value or different kind of software applications that use games for learning purposes such as learning support, teaching enhancement, assessment and evaluation of learners*" (p. 3).

Research interest in the systematic investigation of methods of utilizing digital games as tools for learning has been primarily stimulated by their increased popularity, which can be first of all attributed to their motivating and engaging character. More specifically, digital games present their users with challenging and rewarding experiences (Garris et al. 2002) that motivate them to put effort in order to achieve game goals and objectives (Gee 2007, p. 58). According to Whitton (2004, pp. 38–39), the motivation for becoming involved in the digital gaming activity can be attributed to a range of factors with the mental stimulation that digital games can offer and their potential to facilitate social interactions (taking either the form of competition or collaboration) being considered as two important ones. Furthermore, the fact that game users are able to perform actions and immediately monitor their outcomes, with the help of available feedback, is a key reason for keeping them motivated and involved in game playing (Kirriemuir and McFarlane 2004). On the other hand, engagement can be sustained due to the clear and achievable goals that games possess, their capacity to allow for multiple solution paths with respect to the presented in-game problems, the sense of exercising control to the simulated game world, as well as the curiosity and puzzlement that the presented challenges evoke (Whitton 2009, p. 28).

Given the particularities of school entrepreneurship education in terms of intended learning outcomes, digital games constitute a technological medium capable of supporting their achievement by providing affordances for developing and practicing a range of skills. More specifically, digital games allow their users to adopt virtual identities, explore the virtual world of the game, interact with virtual objects as part of attempts to discover meanings embedded in them, discuss and negotiate with other virtual characters, resolve conflicts, and make decisions (Gee 2007; Kim et al. 2009). Through the presentation of real-world scenarios, in the context of which game users are able to investigate the behavior of game variables and their relations (Tang et al. 2007), digital games offer opportunities for authentic problem solving, inquiry, exploration, continuous practice, and testing of ideas, as part of interactions in the virtual gaming environment, and thus, for involvement in active learning processes (Ke 2009, p. 3; Whitton 2009, p. 28). Apart from that, when used for educational purposes, digital games may facilitate attitudinal changes. To be more specific, through the application of trial-and-error approaches, game users are able to engage in experimentations and learn from their mistakes within virtual spaces where actions have no real-life consequences (Dumbleton and Kirriemuir 2006, pp. 233–240; Kirriemuir and McFarlane 2004; Whitton 2010, pp. 22–32). Therefore, given the context and content of the game, there is potential to develop domain-specific expertise (entrepreneurship-related expertise in our case) in highly interactive and challenging environments, and thus, positive attitudes among game users.

Business simulation games especially, which constitute a subcategory of the simulation games[1] genre, provide close-to-reality models of business operations by attempting to simulate cause-and-effect relations between decisions and their outcomes. As a result, users are able to assume the roles and responsibilities of business managers, become involved in making data-driven decisions, establish connections between theoretical concepts and practice, as well as develop domain-specific knowledge and skills including opportunities to build their own business vocabulary (Ben-Zvi 2007).

[1] A simulation game can be defined as "*a simplified and dynamic model of a real or hypothetical system in which players are in position of competition or cooperation, rules structure player actions, and the goal is to win*" (Sauvé et al. 2011, p. 193).

Outcomes that emphasize the potential of digital games to be used as learning tools capable of supporting school entrepreneurship education have been reported by systematic literature review efforts. According to Connolly et al. (2012), digital game playing can facilitate the development of cognitive skills (e.g., numerical literacy, problem-solving skills, real-world decision making, data handling, and system-based reasoning), as well as lead to behavioral changes and foster social skills. Similarly, Mishra and Foster (2007) mention the development of cognitive skills (e.g., innovative/critical thinking, systemic thinking, inquiry skills, deductive/inductive reasoning), practical skills (e.g., data handling, time management, development of expertise), and social skills (e.g., communication and interpersonal skills, collaboration, identity formation), as well as changes in users' motivation for learning, as some of the most important, and commonly cited, outcomes.

2.3 Approaches to the Evaluation of Entrepreneurship Education Programs

One approach to evaluate the effectiveness of entrepreneurship education programs, whether technology supported or not and independently of the level of education at which they are intended to be delivered, is based on the measurement of their outcomes. As mentioned earlier, outcomes may range from the acquisition of knowledge and the development of entrepreneurial skills to changes in attitudes, perceptions, and intentions toward exercising entrepreneurial behaviors. As Hytti and Kuopusjärvi (2004) point out, evaluation studies should aim, among others, at measuring changes in attitudes toward entrepreneurship, when considering it as a social activity, a career option, or a teaching subject, and highlighting effects at both the individual and group level. As far as the measurement of perceptions is concerned, there should be a focus on learners' perceived understandings of the role of entrepreneurship in societies' prosperity, as well as perceived capabilities of acting as an entrepreneur (Hytti and Kuopusjärvi 2004). The importance of researching potential changes in entrepreneurial attitudes and perceptions is that, according to the theory of planned behavior (Ajzen 1991, 2002), attitudes toward a specific behavior (entrepreneurial behavior in our case) along with perceptions (perceived social pressure and perceived ease or difficulty in performing the behavior), lead to the formation of intentions toward performing the specific behavior, which in turn are valid predictors of the actual performance of the behavior itself. According to the OECD (2009), learning goals and objectives that are to be achieved within the context of entrepreneurship education programs determine outcomes, which in turn may inform the definition of evaluation indicators. The above-described outcomes-oriented approach to the evaluation of the effectiveness of (technology-supported) entrepreneurship education is illustrated with the help of Fig. 13.1.

However, apart from the adoption of outcomes-based evaluation approaches, in the case of technology-supported entrepreneurship education, there needs to be also a focus on the effectiveness of the employed technological medium per se. In order to draw conclusions about the effectiveness of technology- (and in our case game-)

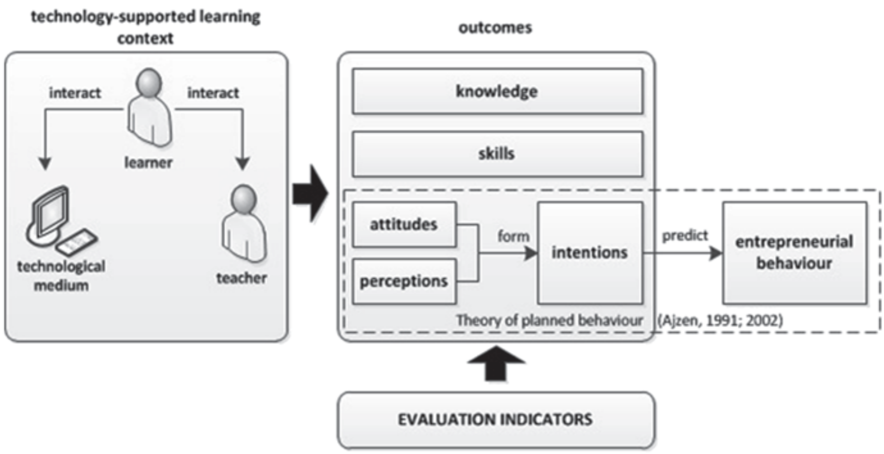


Fig. 13.1 Outcomes-based approach to the evaluation of technology-supported entrepreneurship education

supported entrepreneurship education it is necessary to research the importance of specific characteristics and affordances of the mediating artifact (i.e., the digital game), through appropriately defined evaluation indicators, as well as their correlations with achieved outcomes. Despite the fact that the learning effectiveness of business simulation games has long been investigated, especially in comparison to traditional instructional methods (Faria 2001), most research efforts have adopted evaluation practices that mostly focus on differences between the inputs and outputs of implemented interventions (Kriz and Hense 2006) without attempting to establish connections with affordances of digital games. To this end, after a review of literature on outcomes of game-supported entrepreneurship interventions, as well as existing game-based learning evaluation frameworks that specifically target entrepreneurship education, we present our proposed evaluation framework. Figure 13.2 shows approaches that, apart from providing measures of achieved outcomes, pose also an emphasis on the evaluation of characteristics and affordances of the employed technological medium.

3 Literature Review

3.1 Outcomes of Game-Supported Entrepreneurship Education Interventions

As mentioned earlier, one approach to the evaluation of the effectiveness of (technology-supported) entrepreneurship education is based on measuring outcomes. Within this context, there are a number of efforts, concerned with the design and

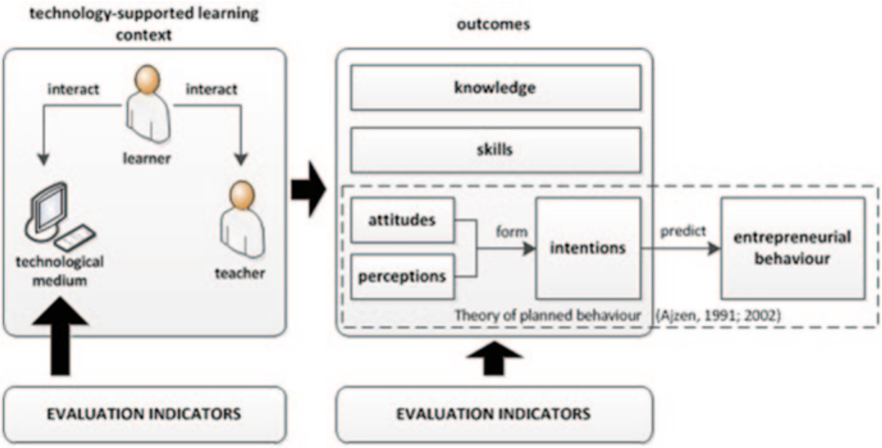


Fig. 13.2 Approaches emphasizing both the evaluation of characteristics and affordances of the technological medium and achieved outcomes

implementation of game-supported learning interventions targeted at entrepreneurship education, which have mostly focused on knowledge acquisition and development of skills. More specifically, Fonseca et al. (2012) present a web-based business simulation game (namely the "PLAYER" game) developed with the aim to foster entrepreneurial mind-sets and promote entrepreneurship as a career option. Through their involvement in game-based activities related to the development of business plans, a total number of 2,706 school and university students across Europe were able to understand the importance of such processes, demonstrate creativity when making decisions regarding the development of their business plans, as well as test alternative ideas. School-based education was also the context of the implementation of a research study by Panoutsopoulos and Sampson (2012), which focused on the design and implementation of a game-based learning scenario targeted at the achievement of mathematics-related educational objectives through the assignment of a business management problem. By taking part in activities, fully supported by the employed game (namely the commercial business simulation game "Sims 2– Open for business"), students of the experimental group were able to demonstrate higher levels of achievement, than their control group counterparts, regarding the application of higher-order cognitive skills (namely "compare and contrast," "explain reasons for," and "evaluate") that are also important for entrepreneurship education. Apart from the reported effectiveness of the digital game-based learning intervention, study participants commented on its innovative character and the potential to investigate and understand real-world situations (i.e., business management issues).

Whitton (2010, pp. 171–174; pp. 183–187) describes two research studies, targeted at post-secondary education, that have been concerned with the use of two different business simulation games (namely "MarketPlace" and "Retail Game") and the participation of undergraduate management students. In the case of the "MarketPlace" game, students were able to collaborate in a competitive environment in order to perform actions related to conducting market analysis, devising marketing strategies, as well as designing and developing products, and monitoring achieved outcomes with the support of provided feedback (Whitton 2010, pp. 171–174). Participants were provided with the opportunity to become engaged in practical application of theoretical concepts, yet they commented on the limited character of feedback which did not allow for insights into cause-and-effect relations between decisions and their outcomes (Whitton 2010, p. 174). With respect to the "Retail Game," Whitton (2010, pp. 183–187) emphasizes the potential to familiarize students with the decisions that need to be made as part of managing a retail store and develop understandings of marketing principles through role adoption, data handling, and application of communication and interpersonal skills.

Williams (2011) presents results from the implementation of a game-based learning approach that aimed at fostering entrepreneurial attitudes and skills among undergraduate management students. Study participants were able to adopt the role of business managers, make decisions with respect to business management, either individually or collaboratively, and monitor their results, as well as experience unexpected events that were built in game scenarios. Curricular topics that were covered included business organization (e.g., resources management), business operations (e.g., product design and quality control), finance (e.g., banking, credit control, and financial analysis tools), and marketing and sales (e.g., market research, pricing, and customer feedback). As far as results are concerned, except for significant effects on the development of entrepreneurial skills, the researcher reports participants' abilities to understand and appreciate entrepreneurship and the importance of joint activity.

Apart from interventions that have taken place in either school-based or tertiary education contexts, a common field of digital game-based learning application is that of vocational training. Lainema and Makkonen (2003) present the effects of a web-based, collaborative, business simulation game (namely "REALGAME") on helping employees cope better with decision-making processes and develop understandings of the complexities that characterize business operations. Through their involvement in appropriately designed game-supported tasks, users were able to gain insights into causal dependencies between decisions and their outcomes by being provided with a holistic view of business operations.

As made evident from the review of literature, digital games can have significant effects on the development of entrepreneurial skills and attitudes, as well as the acquisition of knowledge related to entrepreneurship, mostly because of their potential to allow for hands-on activities and feedback in authentic and meaningful environments. However, it must be noted that the focus on measuring the effects of digital games on the achievement of goals and objectives alone does not help us get the full picture regarding their actual potential to support education in entrepreneurship. It is necessary to research the impact of concrete digital game characteristics and affordances on the effectiveness of game-supported entrepreneurship education. In some of the above-presented efforts, there have indeed been attempts to document associations between characteristics and affordances of digital games and obtained results but not in a systematic manner. As an example, we can mention the quality of provided feedback, as well as the potential for role adoption, handling of data presented in various formats, and decision making. To this end, frameworks that specifically target the evaluation of game-supported entrepreneurship education have been developed.

3.2 Existing Frameworks for Evaluating Game-Supported Entrepreneurship Education

In an attempt to address the issue of evaluating the appropriateness of digital games as tools for supporting entrepreneurship education, Hindle (2002) has proposed an evaluation framework consisting of four evaluation categories, with each category including a number of indicators related to digital game characteristics and contextual parameters. More specifically, the characteristics of digital games and elements of the broader context of implementation of game-based learning that are presented as having increased importance, and are proposed to be evaluated, are the credibility of the game scenario and its alignment with intended learning goals and objectives, the appropriateness and acceptability of the game's sophistication level, the clarity of game rules and operations, the quality of feedback provided by the game as opposed to human-provided in-play feedback, potential game limitations, distinctions between game feedback and learners' assessment and grading, as well as the technical reliability of the game's software and needed hardware.

Within the same context, Hense et al. (2009) have developed and applied a theory-oriented approach[2] that targets the evaluation of the impact of intentional and unintentional outcomes, occurring as a result of interactions between the game, learners, and the teacher, on the contribution of the digital game-based learning approach to the achievement of intended outcomes. The proposed evaluation approach is characterized by a model-based description presenting the implementation of the game-based learning approach as being consisted of three phases-domains (namely the "input domain," the "process domain," and the "output domain"). Each domain comprises a number of elements (variables) that may have direct or indirect effects on the achievement of intended outcomes. The above-mentioned domains and their constituent elements are presented with the help of Table 13.3.

With the digital game being at the core of the context of implementation, Hense et al. (2009) have defined a number of indicators for evaluating the quality of business simulation digital games when exploited for entrepreneurship education purposes. These indicators are the following:

- The rules of the game are clearly defined.
- The roles of the players are clearly defined.

[2] According to Hense et al. (2009), a theory-oriented evaluation approach is a method of evaluation based on theoretical assumptions that underlie the design and implementation of the (educational) program under evaluation.

Table 13.3 Domains of a game-based learning implementation, targeted at entrepreneurship education, and their constituent elements. (Hense et al. 2009)

Domain	Constituent elements
Input domain	*Learner*: previous knowledge and learning experiences, expectancies, and demographic characteristics
	Teacher: teaching/training experience, motivation and expectancies, and preparation
	Learning environment (digital game): quality of content and features that can ensure the learning effectiveness of the game
Process domain	*Learning at the individual level*: intensity of learners' involvement in the performed learning activities and need for an optimal fit between game difficulty and learners' abilities
	Learning at the social level: student-to-student interactions and student-to-teacher interactions
	Interaction with the learning environment (digital game): time-on-task, the appropriateness of performed interactions and debriefing activities
Output domain	*Short-term outcomes*: cognitive learning effects, social learning effects, motivational learning effects, and acceptance of the game by learners and teachers
	Long-term outcomes

- The scenario of the game and the events occurring in the game world are clearly defined.
- The simulation has very good visualizations of the simulated process and structures.
- The simulation includes a good reporting system and a good recording system.
- The game offers a motivating and interesting game scenario.
- The simulation activates the participants to think about interconnections of simulated system elements.
- The simulation activates participants to rate sequences and side effects of problem-solving alternatives.
- The simulation offers a variety of interactions among participants.
- The simulation encourages a variety of perspectives and change of perspectives.
- The simulation offers a link to reality (with rules, roles, and simulated resources corresponding to real, authentic situations).
- The simulation is characterized by an adequate level of complexity for the target group.
- The simulation offers different alternatives of acting and deciding.
- There is a realistic scope of acting and deciding for the players.

A framework for evaluating the learning effectiveness of business simulation games has also been proposed by Faria et al. (2009), who have defined seven key evaluation dimensions. The proposed evaluation dimensions along with their descriptions are presented in Table 13.4.

As made evident from the description of existing frameworks, proposed evaluation dimensions and associated indicators cover a broad set of game-based learning issues, ranging from those related to the technical quality of the medium to peda-

Table 13.4 Dimensions across which the learning effectiveness of business simulation games can be evaluated and their descriptions. (Faria et al. 2009)

Evaluation dimension	Description
Realism	The extent to which game users perceive the simulation to be reflective of real-life situations
Accessibility	Technical requirement focusing on the potential to access business simulation games any time and at any place, as well as the capacity of games to be played either individually or in multiplayer sessions
Compatibility	Technical requirement concerning the capacity of digital games to be played on any platform
Flexibility and scale	Technical requirement related to the potential to change parameters in the game, add or delete modules, as well as make configurations for different participant numbers
Simplicity of use	Defined as how easy the simulation is to be used. Can be divided into: (a) ease of understanding of how to play the game, (b) ease of understanding the observed results, and (c) ease of understanding what is needed to improve performance
Decision support	Refers to in-game functionalities (and sometimes also to non-game-based material) made available to users with the aim to facilitate processes of making decisions in the game
Communication	Refers to team-building processes, team coordination, engagement in joint efforts in the game, and collaborative decision making

Table 13.5 Alignment between existing evaluation dimensions and indicators and categories of game-based learning-related issues

Evaluation framework	Categories of game-based learning-related issues		
	Technical quality	Pedagogical aspects	Psychological factors
Hindle (2002)	√	√	√
Hense et al. (2009)		√	√
Faria et al. (2009)	√	√	√

gogical aspects determining the learning affordances of the digital game and psychological factors that may facilitate participation in game-based learning activities.

However, not all evaluation frameworks, and the evaluation dimensions and indicators defined by them, cover the whole range of the above categories (i.e., "technical quality," "pedagogical aspects," and "psychological factors"). Table 13.5 shows the alignment between the above-mentioned categories and existing evaluation dimensions and indicators.

As a conclusion, we can say that some of the existing evaluation frameworks are more abstract and propose generically defined evaluation dimensions, whereas others, characterized by a higher level of detail, cover only a limited range of game-based learning issues. Thus, there is a need for proposing evaluation frameworks specifically targeted at game-supported education in entrepreneurship that will integrate existing evaluation approaches into the definition of general evaluation dimensions, further analyzed into concrete evaluation indicators.

4 A Framework for Evaluating Game-Supported School Entrepreneurship Education

Except for evaluation frameworks that specifically target game-supported entrepreneurship education, there are also a number of more generic game-based learning evaluation frameworks, which have been considered in the context of our effort. The latter have been developed in order to facilitate systematic processes of digital game selection (based on specific learning affordances that they provide) and reflection upon their educational use in any domain of application (de Freitas and Oliver 2006). Connolly et al. (2008, 2009, pp. 251–273) have developed and proposed a framework for the evaluation of the effectiveness of the context in which digital game-based learning takes place, comprising the following evaluation dimensions: (a) learner performance, (b) learner/instructor motivation, (c) learner/instructor preferences, (d) learner/instructor attitudes, (e) learner/instructor perceptions, (f) game-based learning environment, and (g) collaboration. The "game-based learning environment" dimension is further divided into the following subdimensions: (a) virtual (learning) environment, (b) scaffolding, (c) usability, (d) level of social presence, and (e) deployment (Connolly et al. 2008). From the above subdimensions, "virtual environment" and "scaffolding" are of increased interest for the purpose of proposing our digital game-supported entrepreneurship education evaluation framework. More specifically, there are a number of research issues that need to be addressed within the context of these subdimensions and toward which we have oriented our focus. According to Connolly et al. (2008), these issues relate to the credibility of the virtual gaming environment and its acceptance by users (issues associated with the "virtual environment" subdimension), as well as the quality of provided feedback and the game's employed degree of realism (issue associated with the "scaffolding" subdimension).

Apart from technical quality issues that have been considered by a number of existing evaluation frameworks, our attention has specifically focused on the pedagogical aspects of digital games and psychological factors of engagement in entrepreneurship-related, game-based learning. To this end, we have also been concerned with issues related to the appropriateness of the technological medium (i.e., alignment of the game's content and goals with the intended learning outcomes), as well as its capacity to facilitate interactions and provide adequate support during the execution of the game-based learning activities. Based on the above, we propose an evaluation framework consisting of the following dimensions: (a) realism, (b) game content and goals, (c) credibility, (d) acceptability, (e) in-game support, and (f) interaction.

Despite the previously mentioned emphasis of school entrepreneurship education on the development of generic skills and attitudes, rather than the acquisition of core knowledge and the development of "hard" skills specifically related to business start-up and management, we have also included the "realism" dimension in our proposed framework since it is important to provide learners with a realistic

Table 13.6 Evaluation dimensions of our proposed game-supported entrepreneurship education framework and their definitions

Category of evaluation dimension	Evaluation dimension	Definition of evaluation dimension
Pedagogical aspects of the technological medium (i.e., the digital game)	Game content and goals	Game content is the information with which game users are presented and the tasks that they need to solve in order to advance in the game world (Garzotto 2007)
	In-game support	Feedback provided from the game and taking the form of visual display of information, prompts, advice, warnings, or suggestions for further action
	Interaction	Contribution of the game environment to the generation and negotiation of ideas
Psychological factors of engagement in entrepreneurship-related, technology-enhanced (i.e., game-based) learning	Realism	The extent to which users perceive the simulation/game to be reflective of real-world situations (Faria et al. 2009)
	Credibility	Perceived value of the game as a tool for facilitating the achievement of intended learning outcomes (Beale et al. 2007)
	Acceptability	Conceptualized as perceived ease of use, measured in terms of "ease of understanding how to play the game" and "ease of understanding feedback" (Faria et al. 2009), and perceived enjoyment, measured in terms of "clearness of goals," "challenge," and "immersion" (Garzotto 2007)

environment not in terms of provided graphic representations but with respect to the underlying business simulation model. By this way, learners/game users can reach theoretically sound conclusions about cause-and-effect relations between their in-game decisions and experienced results. Table 13.6 summarizes our proposed evaluation dimensions and their definitions.

The way in which the proposed and defined general evaluation dimensions are analyzed into a number of concrete indicators targeting the evaluation of the effectiveness of (business simulation) digital games, when used in the context of school entrepreneurship education, is presented with the help of Table 13.7.

Table 13.7 Evaluation dimensions of our proposed framework and associated evaluation indicators

Evaluation dimension	Associated evaluation indicators
Game content and goals	The content and the goals of the digital game are aligned with the intended learning outcomes
In-game support	Feedback is available any time and on user's demand
	Game users can easily interpret provided feedback
	The game provides users with all the necessary information for monitoring the operation of their virtual business
	Provided by the game support allows users to develop understandings of the effects of their actions on the virtual business's operation
	Provided by the game support facilitates processes of making decisions and developing strategies with respect to the operation of the virtual business
Interaction	The game facilitates the generation of ideas concerning business management and operation
	The game facilitates the negotiation of ideas among game users
Realism	The game offers a realistic environment for engaging in activities relevant to business management
	The game offers a realistic environment for monitoring the cause-and-effect relationships between decisions and their implications for the virtual business's operation
	The game offers a realistic environment for evaluating the outcomes of decisions and their implications for the virtual business's operation
Credibility	The game helps users build their own business vocabulary
	The game allows users to establish connections between theoretical concepts and their application
Acceptability	Users can easily understand how to use game controls, navigate into the virtual world of the game, and interact with the various game objects
	Users can easily understand the goals of the game
	The management and operation of a virtual business as experienced with the support of the game are challenging

5 Discussion

Entrepreneurship is a key competence for lifelong learning and development that constitutes a significant factor for the economic and cultural growth of today's societies (Commission of the European Communities 2005). School education can play a catalytic role in nurturing an entrepreneurial culture by designing strategies and implementing actions with the aim to equip learners with the necessary skills and attitudes. Available technologies in general and digital games particularly can significantly contribute toward this direction by mediating learning activities designed and performed in the context of broader educational programs and initiatives. More specifically, digital games can offer authentic and meaningful environments, closely related to the culture of young people, where users may engage in continuous practice without being afraid of errors or consequences of their actions. Hence, apart from being able to develop and apply a range of skills, learners can also form positive attitudes toward entrepreneurship by developing domain-specific expertise.

However, in order to document the effectiveness of digital game-based learning in this specific domain of application, we need rigorous evaluation methods. Except for solely adopting outcomes-based evaluation approaches, it is imperative that we focus on the technological medium per se and attempt to investigate the effectiveness of characteristics and affordances of digital games. To this end, we have proposed an evaluation framework that consists of six evaluation dimensions (namely "in-game support," "game content and goals," "interaction," "acceptability," "credibility," and "realism"), further analyzed into a number of concrete evaluation indicators, by taking account of existing game-based learning evaluation frameworks and affordances that (business simulation) digital games specifically offer. The proposed framework may be used either for providing educators with guidelines for appropriate game selection or as a tool for evaluating the effectiveness of digital games in correlation with obtained results regarding the achievement of intended learning outcomes. Providing evidence with respect to how measures of the proposed evaluation indicators correlate with the outcomes achieved by learners/game users will help to gain insights into the actual potential of digital games at the micro level of analysis. Data that can be made available by involved actors (i.e., learners and educators) may be gathered with the help of research instruments, such as interviews and questionnaires, as well as support material, such as appropriately designed worksheets, and games' log files (if made available). Drawing evidence-based conclusions about the effectiveness of digital games, by establishing connections between achieved learning outcomes and game characteristics and affordances, not only will allow for identifying appropriate games but has also implications for the development of specially designed educational digital games specifically targeted at school entrepreneurship education.

References

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes, 50,* 179–211.

Ajzen, I. (2002). Perceived behavioral control, self-efficacy, locus of control, and the theory of planned behavior. *Journal of Applied Social Psychology, 32*(4), 665–683.

Beale, I. L., Kato, P. M., Marin-Bowling, V. M., Guthrie, N., & Cole, S. W. (2007). Improvement in cancer-related knowledge following use of a psychoeducational video game for adolescents and young adults with cancer. *Journal of Adolescent Health, 41*(3), 263–270.

Ben-Zvi, T. (2007). Using business games in teaching DSS. *Journal of Information Systems Education, 18*(1), 113–124.

Chen, Z. H. & Chan, T. W. (2010). *Using game quests to incorporate learning tasks within a virtual world*. Proceedings of 10th IEEE International Conference on Advanced Learning Technologies 2010 (pp. 750–751), Sousse, Tunisia.

Commission of the European Communities. (2005). *Proposal for a recommendation of the European Parliament and of the Council on key competences for lifelong learning*. Retrieved from http://ec.europa.eu/education/policies/2010/doc/keyrec_en.pdf. Accessed 1 Apr 2012.

Commission of the European Communities. (2006). *Implementing the Community Lisbon Programme: Fostering entrepreneurial mindsets through education and learning*. Retrieved from http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2006:0033:FIN:EN:PDF. Accessed 1 Apr 2012.

Connolly, T., Stansfield, M., & Hainey, T. (2008). Development of a general framework for evaluating games-based learning. In T. Connolly & M. Stansfield (Eds.), *2nd European Conference on games-based learning* (pp. 105–114). Reading: Academic Conferences Limited.

Connolly, T., Stansfiled, M., & Hainey, T. (2009). Towards the development of a games-based learning evaluation framework. In T. Connolly, M. Stansfield, & L. Boyle (Eds.), *Games-based learning advancements for multi-sensory human computer interfaces: Techniques and effective practices* (pp. 251–273). Hersey: Information Science Reference.

Connolly, T. M., Boyle, E. A., MacArthur, E., Hainey, T., & Boyle, J. M. (2012). A systematic literature review of empirical evidence on computer games and serious games. *Computers and Education, 59*(2), 661–686.

de Freitas, S., & Oliver, M. (2006). How can exploratory learning with games and simulations within the curriculum be most effectively evaluated? *Computers and Education, 46*(3), 249–264.

Dumbleton, T., & Kirriemuir, J. (2006). Digital games and education. In J. Rutter & J. Bryce (Eds.), *Understanding digital games* (pp. 233–240). London: Sage.

European Commission—Enterprise Directorate General. (2002). *Final Report of the Expert Group: "Best Procedure" Project on Education and Training for Entrepreneurship*. Retrieved from http://ec.europa.eu/enterprise/policies/sme/files/support_measures/training_education/education_final_en.pdf. Accessed 10 Apr 2012.

European Commission—Enterprise, & Industry Directorate General. (2005). *Best Procedure Project: "Mini-Companies in Secondary Education": Final Report of the Expert Group*. Retrieved from http://ec.europa.eu/enterprise/policies/sme/files/support_measures/training_education/doc/mini_companies_en.pdf. Accessed 31 Mar 2012.

Faria, A. J. (2001). The changing nature of business simulation/gaming research: A brief history. *Simulation and Gaming, 32*(1), 97–110.

Faria, A. J., Hutchinson, D., Wellington, W. J., & Gold, S. (2009). Developments in business gaming: A review of the past 40 years. *Simulation and Gaming, 40*(4), 464–487.

Fonseca, B., Morgado, L., Paredes, H., Martins, P., Goncalves, R., Neves, P. et al. (2012). PLAYER: A European project and a game to foster entrepreneurship education for young people. *Journal of Universal Computer Science, 18*(1), 86–105.

Garris, R., Ahlers, R., & Driskell, J. E. (2002). Games, motivation, and learning: A research and practice model. *Simulation and Gaming, 33*(4), 441–467.

Garzotto, F. (2007). *Investigating the educational effectiveness of multiplayer online games for children*. Proceedings of IDC 2007 Conference (pp. 29–36), Aalborg, Denmark.

Gee, J. P. (2007). *What videogames have to teach us about learning and literacy*. New York: Palgrave McMillan.

Hense, J., Kriz, W. C., & Wolfe, J. (2009). Putting theory-oriented evaluation into practice: A logic model approach for evaluating SIMGAME. *Simulation and Gaming, 40*(1), 110–133.

Hindle, K. (2002). A grounded theory for teaching entrepreneurship using simulation games. *Simulation and Gaming, 33*(2), 236–241.

Hytti, U., & Kuopusjärvi, P. (2004). *Evaluating and measuring entrepreneurship and enterprise education: Methods, tools and practices*. Retrieved from http://diogenes.meliusitaly.org/wp-content/uploads/2008/04/evaluating-and-measuring-entrepreneurship-and-enterprise-education.pdf. Accessed 17 Apr 2012.

JISC (2012). *Learning in a digital age: Extending higher education opportunities for lifelong learning*. Retrieved from http://www.jisc.ac.uk/media/documents/publications/programme/2012/JISCLearninginaDigitalAge.pdf. Accessed 15 Jun 2013.

Ke, F. (2009). A qualitative meta-analysis of computer games as learning tools. In R. E. Ferdig (Ed.), *Handbook of research on effective electronic gaming in education* (pp. 1–32). Hershey: IGI Global.

Kim, B., Park, H., & Baek, Y. (2009). Not just fun but using strategies: Using meta-cognitive strategies in game-based learning. *Computers and Education, 52*(4), 800–810.

Kirriemuir, J., & McFarlane, A. (2004). *Literature review in games and learning*. Retrieved from http://telearn.archives-ouvertes.fr/docs/00/19/04/53/PDF/kirriemuir-j-2004-r8.pdf. Accessed 9 Nov 2012.

Kriz, W.C., & Hense, J. (2006). Theory-oriented evaluation for the design of and research in gaming and simulation. *Simulation and Gaming, 37*(2), 268–283.

Lainema, T., & Makkonen, P. (2003). Applying constructivist approach to educational business games: Case REALGAME. *Simulation and Gaming, 34*(1), 131–149.

Mishra, P., & Foster, A. (2007). *The claims of games: A comprehensive review and directions for future research*. Proceedings of the 18th International Conference of the Society for Information Technology & Teacher Education (pp. 2227–2232), San Antonio, USA.

OECD (2009). *Evaluation of programmes concerning education for entrepreneurship*. Retrieved from http://www.oecd.org/dataoecd/19/31/42890085.pdf. Accessed 6 Jul 2012.

Panoutsopoulos, I., & Sampson, D. (2012). A study on exploiting commercial digital games into school context. *Educational Technology and Society Journal, 15*(1), 15–27.

Sampson, D., & Fytros, D. (2008). Competence models in technology-enhanced competence-based learning. In H. H. Adelsberger, Kinshuk, J. M. Pawlowski, & D. G. Sampson (Eds.), *Handbook on information technologies for education and training* (pp. 155–177). New York: Springer.

Sandford, R., & Williamson, B. (2005). *Games and learning*. Retrieved from http://www2.futurelab.org.uk/resources/documents/handbooks/games_and_learning2.pdf. Accessed 2 Jan 2008.

Sauvé, L., Renaud, L., & Kaufman, D. (2011). Games, simulations, and simulation games for learning: Definitions and distinctions. In K. Klinger, L. Johnston, & D. Earnest (Eds.), *Gaming and simulations: Concepts, methodologies, tools and applications* (pp. 168–193). Hersey: Information Resources Management Association.

Tang, S., Hanneghan, M., & El-Rhalibi, A. (2007). *Pedagogy elements, components and structures for serious games authoring environment*. Proceedings of the 5th International Game Design and Technology Workshop 2007 (pp. 26–34), Liverpool, UK.

Tang, S., Hanneghan, M., & El-Rhalibi, A. (2009). Introduction to games-based learning. In T. Connolly, M. Stansfield, & L. Boyle (Eds.), *Games-based learning advancements for multi-sensory human computer interfaces: Techniques and effective practices* (pp. 1–17). Hersey: Information Science Reference.

UNESCO. (2005). *Towards knowledge societies: World report*. Retrieved from http://unesdoc.unesco.org/images/0014/001418/141843e.pdf. Accessed 26 Oct 2012.

Van Eck, R. (2007). Building artificially intelligent learning games. In D. Gibson, C. Aldrich, & M. Prensky (Eds.), *Games and simulations in online learning* (pp. 271–307). Hersey: Information Science Publishing.

Whitton, N. (2009). Learning and teaching with computer games in higher education. In T. Connolly, M. Stansfield, & L. Boyle (Eds.), *Games-based learning advancements for multi-sensory human computer interfaces: Techniques and effective practices* (pp. 18–33). Hersey: Information Science Reference.

Whitton, N. (2010). *Learning with digital games: A practical guide to engaging students in higher education*. New York: Routledge.

Williams, D. (2011). *Impact of business simulation games in enterprise education*. Paper presentation of the 2010 University of Huddersfield Annual Learning and Teaching Conference, pp. 11–20. Retrieved from http://eprints.hud.ac.uk/9651. Accessed 17 Apr 2012.

Chapter 14
Stimulating Learning via Tutoring and Collaborative Simulator Games

António Alves, Anabela Maria de Sousa Pereira, Hélder Castanheira, Inês Direito and A. Manuel de Oliveira Duarte

1 Introduction

The main goal of teaching in higher education is to foster autonomous knowledge construction and skill development. Considering the present knowledge society and the demands of the socioeconomic environment, the learning processes cannot be limited by traditional teaching frameworks. Although teaching in the traditional system, in either a formal or informal way, is necessary and, in some knowledge areas, irreplaceable, the use of other teaching and learning approaches is crucial. This chapter presents two initiatives developed at the University of Aveiro addressed to enhance students learning: (1) a tutoring system, to support undergraduate students' learning in science, technology, engineering, and mathematics (STEM) subjects and tools, and (2) a simulator game to support telecommunication engineering students' learning and entrepreneurship.

A. Alves (✉) · A. M. d. O. Duarte
Department of Electronics, Telecommunications and Informatics, University of Aveiro, Campus Universitário de Santiago, 3810-193, Aveiro, Portugal
e-mail: aalves@ua.pt

A. M. d. O. Duarte
e-mail: duarte@ua.pt

A. M. d. S. Pereira · I. Direito
Department of Education, University of Aveiro, Campus Universitário de Santiago, 3810-193, Aveiro, Portugal
e-mail: anabelapereira@ua.pt

I. Direito
e-mail: ines.direito@ua.pt

H. Castanheira
Social Services, University of Aveiro, Campus Universitário de Santiago, 3810-193, Aveiro, Portugal
e-mail: helder.castanheira@ua.pt

D. G. Sampson et al. (eds.), *Digital Systems for Open Access to Formal and Informal Learning,*
DOI 10.1007/978-3-319-02264-2_14,

1.1 Background

The profound mutations that took place over the past decades in terms of enabling technologies, emerging business models, and organizational structures challenge continuously the labor market and demand, more than ever, a competent and flexible workforce. The labor market looks for graduates equipped with the competences required by the new professional environment. However, successful recruitment is hard to achieve, as recent graduates are considered not sufficiently prepared with knowledge and skills to face the uncertainties of the market. They frequently lack some fundamental soft skills such as problem-solving, teamwork, communication and the ability to learn continuously and autonomously.

Higher education institutions have responsibilities in preparing their graduates to work competently and deal with unpredictable challenges. Despite this, higher education curricula are still characterized by a strong emphasis on theoretical science and technology disciplines instead of assuming more practical approaches. STEM disciplines are essential requirements to prepare students with the analytical skills that an engineer must have. However, this preparation on propaedeutic and specific subject matters of each engineering field frequently is not accompanied by an effort to prepare students about equally important nontechnical aspects of their profession. These shortcomings are particularly felt in relation to soft skills such as planning, organization, and interpersonal communication. All this is further aggravated when they have to work within a team. In addition, it is also frequent that during their courses, students develop very little awareness about the outside world, namely about the markets where soon they will be looking for a job or struggling to keep it.

For many engineering graduates, when starting a career, the unsuitability of companies' demands and educational programs results in serious behavioral mismatches and very limited knowledge about the activity sectors and businesses where they become involved. These circumstances can represent an important handicap in their careers, and the resulting limitations can significantly impair their capability to play the roles that enterprises expect from them. In addition, these weaknesses also do not favor the emergence of an entrepreneurial spirit (Smith et al. 2006) among young engineers, restricting their ability to contribute to economic and social growth. Ultimately, all this can jeopardize their employability.

This situation creates new responsibilities on the part of higher education institutions. Curricula should match industry needs, not only in terms of contents but also in terms of pedagogical approach. Learning processes should be focused on the learner, captivating his/her interest and promoting active and autonomous competence development. Problem-based learning and tutoring are student-centered methodologies that support these challenges.

2 Promoting Learning by Tutoring Support Tools

There are many different approaches that can be used to complement the traditional "classroom system." Nonetheless, one of the most known and considered approaches in many schools and colleges is the tutoring systems where a teacher, an advanced student, or a peer colleague who knows more about certain subjects, helps or supports tutored students' learning.

The tutoring advice or assistance, in either a more formal or an informal way, is based on the tutorial method that was first developed and implemented by Cambridge University and Oxford University. These tutorial methods consisted in organizing a small and limited group of students, where they were stimulated to debate and argue in the subject they are focusing their studies on, and to analyze it under the orientation of the tutor. The tutor not only is usually a teacher or trainer but also can be an experienced or an advanced student (Moore 1968; Palfreyman et al. 2008).

Although all the methodologies and proceedings behind a tutorial support and assistance program are important to implement and guarantee the success of the tutoring, the use of well-spread and accessible resources is essential. Among these resources, the new technologies such as computers, smartphones, websites, and services are some of the most significant and useful ones to be considered in a modern tutoring process. In fact, these technologies have been replacing the first resources used before the information systems and technologies (IST) were universally available to students, teachers, and any common person (Fedorov 2007).

Even though the Internet has a great potential to improve and create new tutorial services and resources that are helpful to the learning process, the human relationship between students and teachers should not be faltered due to the use of Internet and its easy access regardless of the learning subject, place, and time. If a tutorial assistance program starts to rely mostly on the technology and its resources, even that for some students this can be very attractive, for other students this situation can bring some difficulties and new ways of isolation can start since everyone is not limited to the formality of classroom (Ozad and Kutoglu 2010; Vagos et al. 2010).

With the intention of creating a tutorial program that could be used to promoting the learning process, and also addressing the problems identified before, a project called LUA-iNova was deployed at the University of Aveiro. This project was responsible for analyzing and evaluating the advantages and disadvantages of information and computing system and technologies in a tutorial program that could be based on both defined types of tutors (Duarte et al. 2011b):

- Physical tutor—where a person (teacher, advanced student, etc.) is responsible for conducting and supervising the tutorial session and sequence, though other resources can be used (television, radio, Internet, etc.)
- Media tutor—where a medium (television, radio, Internet, etc.) is used to guide and organize the tutorial session and sequence, though a person (teacher, advanced student, counselor, etc.) can also be available to support or assist occasionally when extra help is needed.

2.1 Tutorial Supporting Tools

As mentioned earlier, the LUA-iNova project has the main goal of helping students with learning problems by giving them a tutorial program that can support their learning processes. In order to reach its goal, this project needs, not only, to consider that a majority of learning gaps of students are usually related with personal and social problems than with the learning process itself, but also know and understand how technology changes education and how it can be used to promote the learning process (Bates and Poole 2003; Kent and McNergney 1999).

To address the former this problem, the experience obtained by the initiative and program still running LUA was possible to denote that advanced students with more ability and experience could deal much better with personal and social problems, and also with academic life, in comparison with the more inexperienced students. In fact, while some students can organize their life in order to study and accomplish their academic tasks and, if necessary, help their colleagues, others simply cannot deal with their problems and also are not capable of asking for help or tutorial orientation and support (Duarte et al. 2011a; Direito et al. 2010).

Although universities were the first to introduce tutorial support to help their students, some institutions realize the great potential and opportunity of helping students from all the stages of education. Among the several examples, there are paid services such as Exeter Tutorial College (www.tutorialcollege.com), Tutorial Services, (www.tutorialservices.org), Great Mind Tutoring (www.greatmindsnw.com), and also free services such as Wikiversity (en.wikiversity.org), W3Schools (www.w3schools.com), BBC Learning (www.bbc.co.uk/learning), which typically offer more diversity and quantity of information, and resources than other universities' tutorials, be it in dedicated matters and subjects or in more generic and embracing subjects.

After some study and research, the architecture of the LUA-iNova system was defined as illustrated in Fig. 14.1.

2.2 Requirements and Specifications of a Tutorial Tool

The IST currently available (computers, websites and services, software, etc.) make the process of producing, cataloging, sharing, and accessing tutorials simple and easy for anyone. In spite of the amount of available resources, the quality of the tutorials will only be guaranteed if special care is taken with the following aspects:

- Developing tools (software, websites, etc.) that are easy to use by both, students and tutors
- Designing a website that allows effective and organized cataloging of the tutorial resources for future use
- Ensuring quick and simple search features in the website
- Providing answers to the students' needs, problems, and difficulties

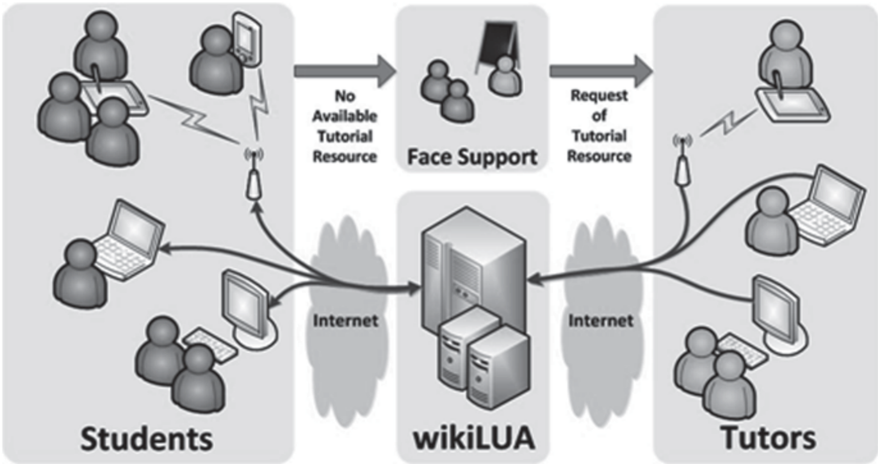


Fig. 14.1 LUA-iNova tutorial support program structure

Although the previous topics are essential, it is also very important to highlight that a good quality and presentation of the tutorial resources should be considered to ensure a comprehensive and efficient approach to the subjects addressed by the tutorials (Wales 2008).

To achieve the above requirements it was decided to use tutorials of the screen recording type, which are easier for the tutors to create, edit, and produce. Video tutorials are also much easier to reuse and update. On the other hand, students are more open and focused when using visual resources (Furse 2009; Stannard 2009).

The tutorials should also follow some specifications not only to guarantee their quality as useful resources but also to accomplish the requirements defined to the website tool, in order to be complemented by each other. The specifications are the following (Furse 2009):

- Each tutorial should be prepared for a specific and particular subject.
- The tutorial's length should not exceed more than 5 min, so that it could be easier for students to learn a particular subject.
- It is important to avoid repetition of subjects in order to clearly present the subject, permitting students to access a particular section of the tutorial when they need it and want it.
- A good preparation and organization of the topics to be included in the tutorial are essential to create a structured and comprehensive tutorial.
- Ensure an easy, simple, and universal access to the tutorial resources.

Regarding the previous specifications, a website called wikiLUA was designed that follows the architecture presented in Fig. 14.2.

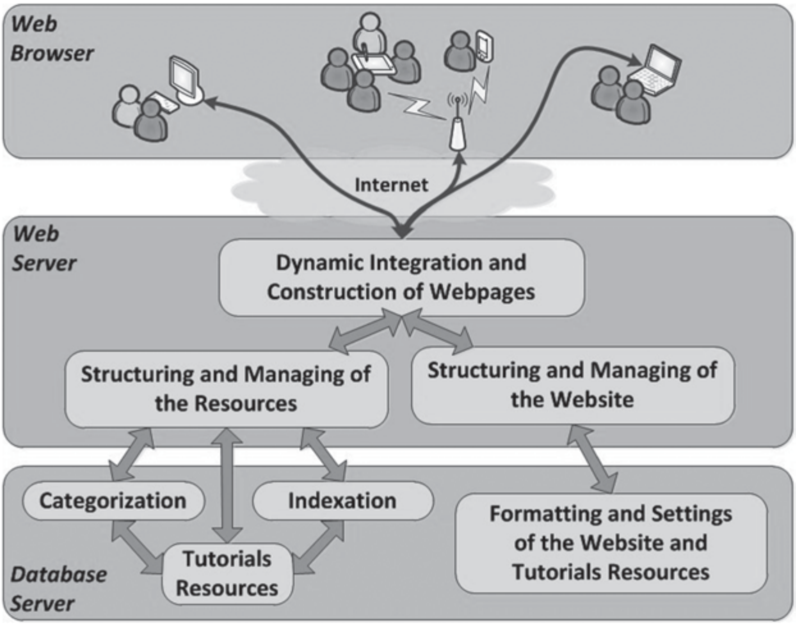


Fig. 14.2 Internal architecture of the wikiLUA website

This architecture is organized in three levels/layers:

- Database server—where all the tutorial resources are stored, as well as all the formatting and setting applied to both the resources and the website
- Web server—where the tutorial resources and the website are structured, organized, and formatted according to the settings and configuration stored in the database, in order to be dynamically constructed/designed webpages to be access by users
- Web browser—browser of the user where the contents are displayed according to the structure and formatting stored in the database

2.3 wikiLUA

The wikiLUA website is a Web system that supports and makes available the tools that can be used to create, edit, produce, and share tutorial resources. This website was implemented following the requirements and specifications defined and detailed in the previous section.

Since the creation and sharing of a large amount of tutorial resources can become a possibility in these systems, their access can become slower if the system architecture behind the website does not have some characteristics. The wikiLUA website is a new starting project that does not, yet, need any special features because its needs, at the present moment, are at the level of a prototype. However, wikiLUA aims to be a site that will gather and manage hundreds, or even thousands, of tutorial resources. For that reason, it was important to follow the architecture presented in Fig. 14.2, and also to consider the specific details.

wikiLUA was structured and organized to consider a database layer in such a way that all the settings and optimizations made at the software level in the upper layers (interface and Web) are stored in the database as formatting settings. Using the same idea, all tutorials were stored according to a category and index, which provide an indexing service that allows fast and correct access to the tutorials resource. These features allow the database to flexibly and autonomously index and categorize tutorials, increasing the size and complexity of database.

The interface layer is running on a Web server where the data stored in the database will be processed in order to format the site and tutorial resources to be used by the students.

The Web layer is the browser used by students where all the formatting and tutorials are rendered to be seen. This layer depends and relies on the commercial browsers.

Since the conceptualization, development, and implementation of such a website would require a lot of time and consume many human and economic resources, it was considered to use the content management system MediaWiki, which is used on the site Wikipedia, one of the biggest sites in the world, that holds features and specifications that fulfill the requirements previously defined.

After all the necessary configurations, optimizations, and customizations to implement the wikiLUA website, the result was a site with a "Wikipedia" style, as it can be seen in Figs. 14.3 and 14.4, but holding features that suit the requirements specified.

2.4 Test and Validation

Before the usage of the wikiLUA website tutoring tool by the students, a minimum set of tutorials were designed and uploaded. Therefore, the first users of wikiLUA were tutors, who had to create, edit, and upload tutorial resources, and only then, it was available to the students.

Consequently, the tests and validations of the tool were divided into the following actors/agents:

- The tutors, who have the main responsibility for the tutorial resources on wikiLUA, were asked to focus their attention and appreciation on the details related to the accessibility, usability, response, easiness, feasibility, quality, accuracy, security, and privacy from the tutor's point of view concerning the creation and production of tutorials and the upload of these resources on the website.
- The students, who intend to access and use the tutorial resources of wikiLUA, were asked to focus their attention and appreciation on the topics of the tutor,

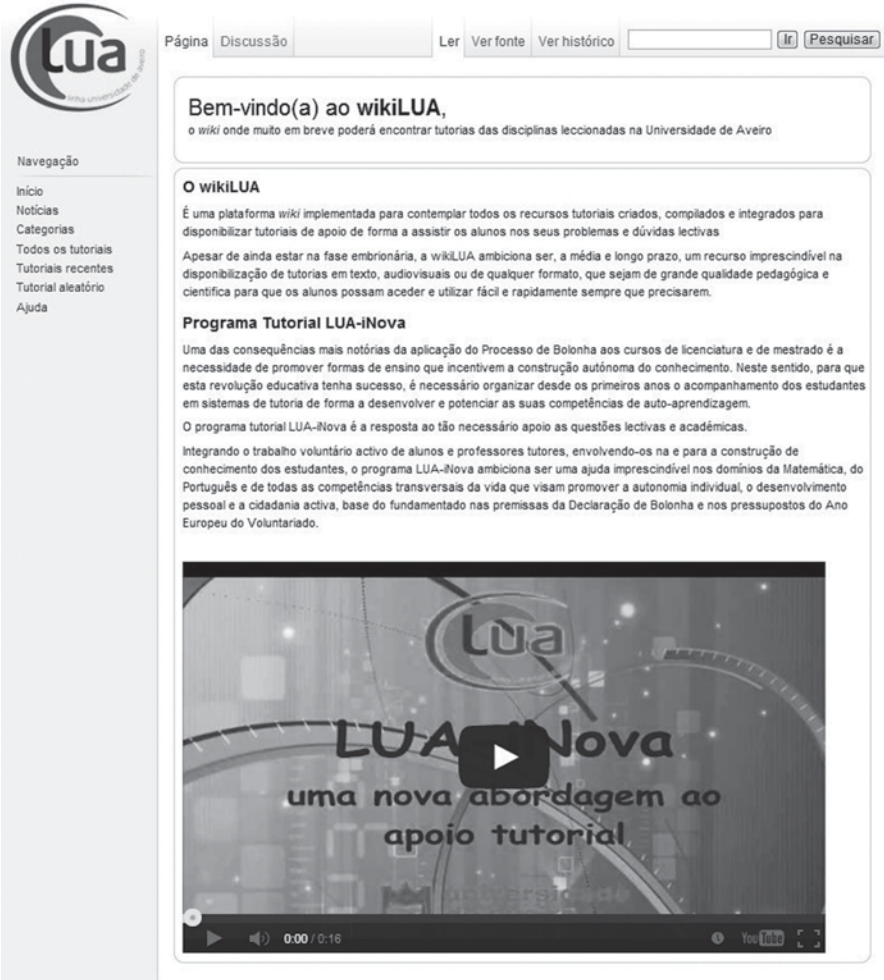


Fig. 14.3 Homepage of the wikiLUA website

but from the point of view of a user who wants to learn and understand specific academic subjects when using the website's tutorial resources.

- The guests, who are users doing a casual Web search for help or examples on particular subjects, were asked to give their first impression of user experience of the wikiLUA website.

Based on the details mentioned before, and to guarantee that the tests were not influenced by the request of specific tutorials, which could influence the attention on the tutorial rather than on the tool, the first tests of the website wikiLUA, as a

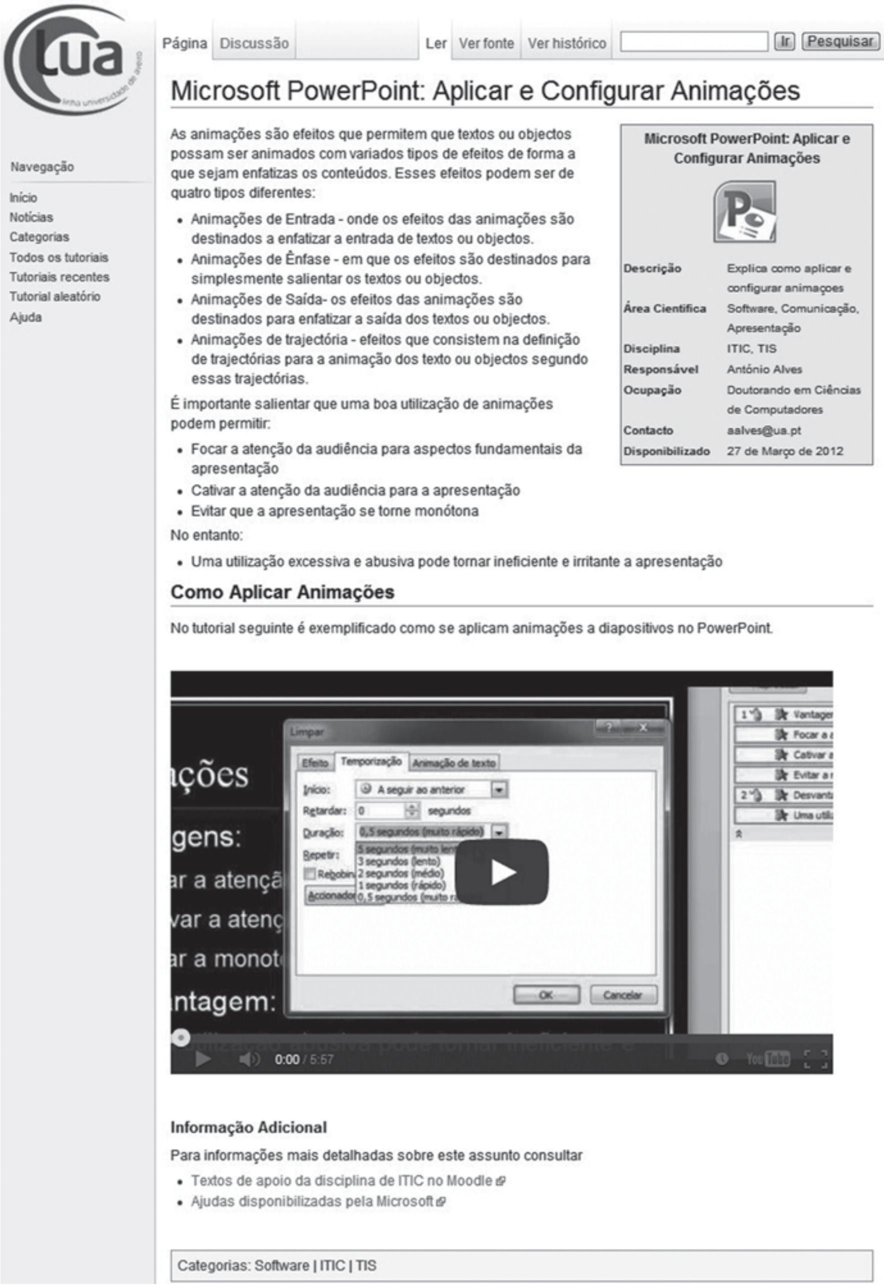


Fig. 14.4 A tutorial resource in the wikiLUA website

tutoring tool, were done by the tutors, then by the students, and finally by the guests. This sequence was defined to avoid influences and effects between types of users.

The first groups of users involved in the tests were teachers and students of three courses of the University of Aveiro where productivity software (Microsoft Office®, LivreOffice®, etc.) was incorporated as a mean of supporting written and oral communication and also basic calculation activities. These courses were selected for being initial areas where students already have some experience but need to strengthen their skills, and tutors do not need to spend too much time for preparation, since they already have done some work and also have adequate experience to start creating, editing, producing, and deploying tutorial resources.

To start the use of the wikiLUA website, tutors were trained in an extensive preparation program where they also received a quick guide and a comprehensive manual. Tutorial resources and online helpdesks where tutors could ask for help were also made available.

The test and validation of wikiLUA, regarding the tutors' perspective, were done through the process of making tutorial resources and preparing the wikiLUA website. There were regular meetings to share and discuss new ideas, different points of view, new approaches, bugs, and possible improvements. In addition, in the end of all these processes, tutors were asked to answer a simple survey from where it was possible to extract information useful to improve the website.

As soon as wikiLUA was ready to be available (something close to a prerelease version), students were invited to access, search, and use the tool. An online helpdesk to help students in any question, difficulty, or problem they find during their experience was offered. After some time of usage, students were invited to answer a survey about their experiences on the wikiLUA website. Something similar was done with the guest users. The main difference was that guest users were randomly selected and asked to access, search, and use the website for a couple of minutes, and after that they only needed to answer some simple questions about the wikiLUA website.

2.5 Assessment of the Experience's Impact on Student's Learning

In the first weeks of the wikiLUA website being available, the first analyses were done, which showed that the first results were not so "encouraging" as expected. The majority of the students liked the idea of wikiLUA, but they were expecting much more from the website.

They were initially expecting a website with thousands of tutorials, where it could be possible to find answers for all of their questions. In fact, they quickly started to compare wikiLUA to YouTube®, and making comparisons of different aspects and characteristics of both services.

The other initial reaction was that they thought that the website was to be a substitution of the traditional tutorial support and not a tool to help and complement

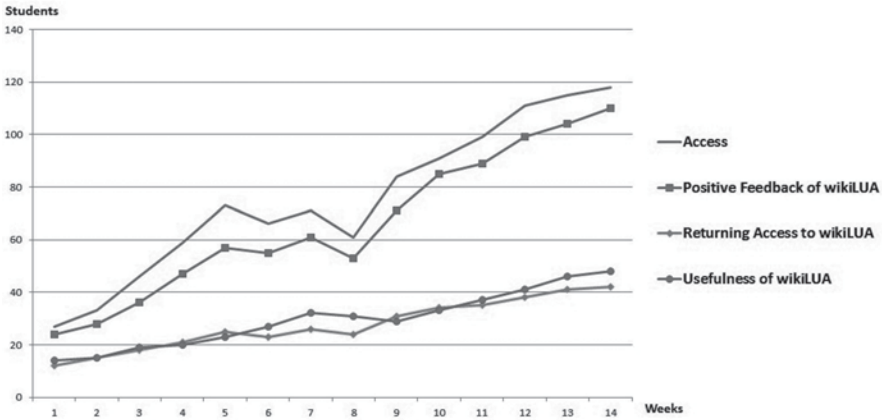


Fig. 14.5 Measures of the use of the wikiLUA website as tutorial support tool

the traditional support. This situation led some students to think that they could have more learning difficulties because any tutorial in those particular subjects was not available, or, worse than that, they do not need to worry about their doubts since nothing about those subjects was available, and therefore it should not be so important.

After the first misinterpretations, the students started to understand more clearly that wikiLUA was part of a project called LUA-iNova that intended to use i IST to help and complement the traditional way of tutorial assistance and support. At that point, things started to run normally with a dynamic and very interactive use of wikiLUA by the students. This situation also was a consequence of the fact that more students were involved in the tutorial program and therefore they were helping and guiding each other.

Soon, the use of wikiLUA inside the LUA-iNova project was clarified, and it was possible to collect some interesting and useful measures. First details are shown in Fig. 14.5.

Regarding students' answers, it is possible to see that the majority of the students who accessed and used wikiLUA gave a positive feedback about wikiLUA and its usefulness. It is also possible to see that some students returned to access wikiLUA. Also, students answered that they understood more quickly and easily the subjects found in wikiLUA, and that it helped them to clarify their doubts and difficulties.

Overall, it can be concluded that, even though the process is slow, the number of students who return to use wikiLUA are increasing. Also, the students who return are being more efficient in solving their difficulties, learning gaps, and doubts about the subjects they search. Although at this point it can be concluded that wikiLUA is a successful tool, if the number of students using the tool continues to increase, this conclusion will supported.

2.6 Assessment of the Experience's Impact on University Teaching Performance

The results of this project under the university performing perspective are difficult to be quantified, since the main focus of the project is the students' problem and difficulties rather than the university performance. Another main reason for the absence of more and detailed data, that possibly could be used to extract more measures, is the fact of the LUA-iNova project still is under development and implementation. However, with the initial information obtained from the surveys conducted with students and tutors, it was possible to gather the presented data and correlate them with some measures and statistics from the university.

It was possible to see that students frequenting the initial years of their courses were, less than usual, requesting and using the orientation and explanation-offered extra classes available in all the courses delivered in the University of Aveiro.

Although these results cannot be completely related to the LUA-iNova project and the wikiLUA tutorial tool, it could be that this tool has positively influenced the performance of the extra classes and, probably, the lectures itself, which is very encouraging and states a good starting point for further developments and expansion of the tutorial program in the university.

3 Promoting Learning with Simulating Games

Over the past years, a study has been conducted encompassing approximately 250 students of engineering courses (higher education) and approximately 500 students of foundation courses (postsecondary education; Duarte and Direito 2009), in order to gain a better understanding about the matching between industry needs and curricula, and also to prepare future actions. This study addressed the following aspects:

- Student's representations with respect to the specific subjects of study of their courses
- Representations of enterprises that received either young graduates or trainees from engineering and foundation courses

Among the findings of this study, it is possible to highlight the following aspects:

- Engineering and technology students receive tools for solving problems that they have never faced before and for which they do not have an adequate appreciation.
- Because of their limited real-world experience, engineering and technology students have difficulty in understanding the practical applications of their studies.

Another frequent feeling among many engineering students is that they find that classes were boring (Anderson et al. 1996). Previous research (Duarte and Direito 2009) found that this is mainly due to the following causes:

1. Because of their limited real-world experience, students have difficulty in understanding the practical applications of their studies.
2. As a direct consequence of the traditional universities' teaching approach, students receive tools for solving problems that they have never faced before and for which they do not have an adequate appreciation.

In summary, many students do not develop meaningful knowledge and competences and this is caused by the adopted pedagogical approaches that do not promote active learning.

With role-playing approaches, students are engaged in authentic real-world problems and active learning, having the opportunity of learning by doing, receiving feedback, continually refining their understanding, and building new knowledge (Bransford et al. 2000). Simulators can enhance this experience by reproducing complex scenarios and by reducing, considerably, training costs and resources. Training simulators are being used in engineering education, supporting hands-on experience and student motivation in the learning process (Cooper and Dougherty 2001; Fournier-Viger et al. 2008; Gomboc et al. 2008)

3.1 Role-Playing: Promoting Active and Meaningful Knowledge

In order to provide answers to the problems identified in the study outlined previously, a pedagogical initiative was launched targeting the promotion of active and meaningful knowledge creation in engineering students. This initiative is currently taking place in the context of several courses in the area of electrical engineering (with majors in telecommunications and information systems) at postsecondary, BSc, and MSc levels (Bologna system). The basic concept behind it is rooted on a capstone-like project where groups of students play the role of telecommunication companies competing against each other, resorting to decisions that they have to make based on sound engineering studies: technology choices, network design and dimensioning, market simulation, and economic–financial analysis.

This initiative is intrinsically dynamic, learner centered, and more experiential than traditional ones. It represents an attempt to improve student's classroom involvement, bridging the gap between the engineering profession and the classroom, attempting to contribute towards better success rates and improved employability. It also helps the development of professional identities. The initiative followed two phases:

1. Definition of project ideas was made with the contributions of practicing engineers from several companies who are invited to present some of their real-work challenges in a series of seminars. Students engaged in weekly discussion sessions with practicing engineers and experts (industrial guest speakers) in order to exchange ideas and discuss career paths. The main objectives of these sessions were: provision of the "big picture" about core characteristics of what telecommunication engineers do, exposition to positive role models, and encourage questions and understanding.

2. Projects were designed around a situation where teams play the role of competing companies in a market place. Competition initiatives among teams playing the roles of competing companies in an open market were delivered, in order to expose students to business dynamics (Carpio et al. 2007).

This leads to an atmosphere of project-based active learning combined with an interactive entrepreneurial atmosphere in the area of telecommunications engineering. The role-playing competitions followed three steps:

1. Faced with a specific challenge (as will be outlined ahead in the chapter), each team tries to identify possible solutions and must make its evaluation, both in technical and economic terms.
2. Chosen solutions must be converted into a business case, with different teams playing the roles of competing companies in a marketplace.
3. A didactic market simulator is used to create conditions similar to those found in real markets and to convey experimental lessons transferable to the real world.

A description of this market simulator is provided subsequently.

3.2 The Didactic Market Simulator

Training simulators are designed for education purposes, providing significant hands-on experiences that motivate and facilitate learning (Kartam and Al-Reshaid 2002). Additionally, they can also offer experiences that resemble those of the real world and, thus, can give students the opportunity to apply theory in an efficient, economic, and interactive fashion.

The work described in this chapter was supported by the usage of a didactic market simulator that can be used to make students familiar with the dynamics of the telecommunication sector. It can easily be transposed to other economic sectors. Its structure, in its present state, is depicted in Fig. 14.6.

3.3 Purpose of the Didactic Market Simulator

The simulator is designed so that students will learn how telecommunication engineering decisions (e.g., network architecture, physical media, bandwidth, latency) associated with marketing, economic, and financial decisions (e.g., offered services, tariffs, competition among operators, etc.) affect the overall network performance and the ways markets react.

In a preliminary phase, Excel was used as the basic platform. This enabled some fine-tuning of the mathematical model and also proved very useful for the determination of several parameters. At a later stage, the implementation was migrated to a Web environment supported by database and appropriate query languages.

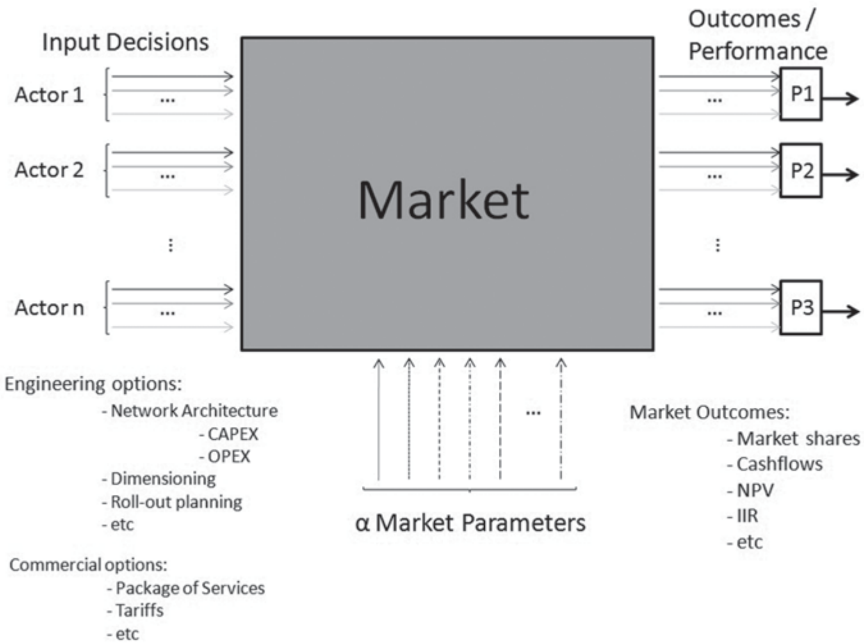


Fig. 14.6 Didactic market simulator structure

Figure 14.7 illustrates some screen shots obtained with the market simulator in a Web environment.

3.4 Test and Validation

In order to test and validate the approach described in this chapter, a series of experiments were conducted over the past 2 years. This was done in the context of a capstone project in the third year of an MSc in electronics and telecommunications engineering (total duration of 5 years: 3 years of the first cycle and 2 years of the second cycle).

The basic objective of this capstone project is to make students face the challenge of projecting an access network using up-to-date technologies (e.g., fiber-to-the-home, LTE, WiMAX, etc.) and evaluating the different architectures (point-to-point, point-to-multipoint, etc.), different engineering solutions (active, passive, etc.), and roll-out strategies (market size estimates, time plan of investments, tariffs, etc.). In this work, students are required to integrate knowledge and skills developed in other disciplines, probably over a period of several years.

To estimate (quantitatively) the impact of the approach described in this project on student learning and understanding, during 3 weeks of a semester (over the

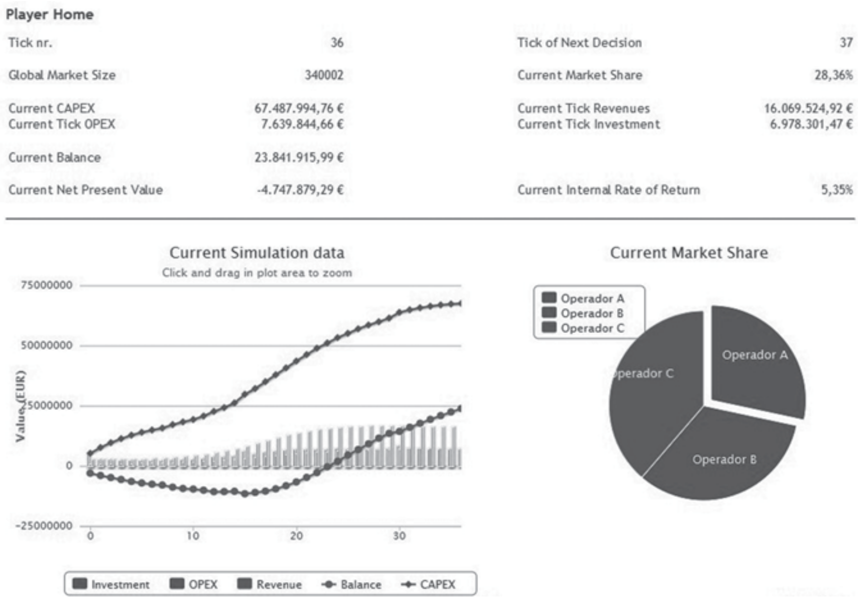


Fig. 14.7 Screen shots obtained with the market simulator (investment analysis in an access network with three operators)

last academic years), the class (45 students, average) was given an assessment test (multiple-choice questions) on access networks (a subject not specifically studied in the preceding 9 weeks, and which requires the integration of knowledge and skills developed in other disciplines, over a period of approximately 2 years before the capstone project and the market simulator was introduced).

After this test, the class had the opportunity to attend a seminar (1 h) by an invited senior telecommunications engineer responsible for the access network planning in a major telecom operator. Here, students had the opportunity to witness some of the challenges faced by a telecommunication engineer in planning, designing, and operating an access network under severe market competition conditions. At this point, the class was split into nine groups of five students for a short period (1 h) doing hands-on familiarization with the market simulator. This was followed by a period of two more working sessions (4 h over 2 weeks) where the class was organized into sets of three groups. In each set, each group played the role of a telecom operator competing with the other.

TabletPCs were made available for these sessions in order to facilitate interaction and discussion of ideas inside groups and among groups.

In the first of these two sessions, every group started with equal market share as the other groups. Following a choice of engineering options related to the specific access network under consideration (architectures, active or passive network elements, market size estimates, expected competition, time plan of investments, tariffs, etc.), the simulator produced the market share situation for every competitor,

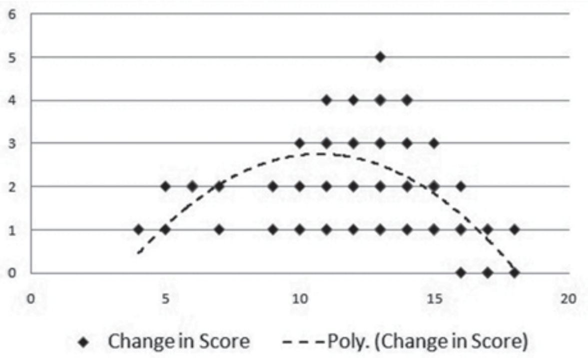


Fig. 14.8 Impact of the capstone project approach on student outcomes

corresponding to half of the study period under consideration. During the period until the following session, in the week after, every group tried to devise possible strategies to either recover from the bad position where the first run had left them or to keep the advantage that eventually they had already obtained. The second run dictated the final results of the market game.

After this experience, an assessment test on access networks as similar as possible to the original one (but not equal) was given again to all 45 students in order to measure eventual changes in student learning and comprehension.

Figure 14.8 shows the aggregate results of these tests over several academic years.

3.5 Assessment of the Experience's Impact on Student's Learning

The results obtained, in spite of referring to just two runs of the experiment over the past years (others will follow in subsequent years), were very encouraging:

- The classes, as a whole showed an average improvement of 2.06 points (out of possible 20), that is, approximately 10.3 %.
- It was interesting to notice that the improvement was particularly significant in students with average marks, where the vast majority of engineering students do stand more frequently.

The above results were complemented by a set of (informal) interviews with a sample of 10 students (out of 45), in both academic years, in order to gain some feedback about how students felt with the experiment. The outcome of these interviews was generally very positive, underlining particularly the following aspects:

- The very positive effect of having a practicing engineer sharing with students some of his/her professional experience in problems very similar to those that they were facing in the capstone project (a typical case of "situated learning"; Anderson et al. 1996)

- Having the possibility to play with the didactic market simulator proved to be extremely useful to integrate and consolidate previous learning, to help gain a better understanding of businesses dynamics, and to improve teamwork

3.6 Assessment of the Experience's Impact on Employers

Given the fact that the experiment was done with students attending their last year of the first cycle of the engineering degree (Bologna type), it was possible to track some of these students in their first employment. This was done with a group of five students who graduated in the previous years. Results are being subsequently updated with groups of students from the succeeding course editions.

As part of this exercise, several interviews were conducted with responsible personnel of the employing companies following the first 3 months of employment of the graduates.

In spite of the limited statistical value that this limited number of enquiries might have, it is very encouraging to notice that, in general, they seem to point out the following: As compared to their company colleagues, test graduates exhibit better teamwork skills, show good ability to integrate and associate knowledge from different fields, and reveal good understanding of the telecommunication business markets.

4 Conclusions

In the present education contexts, it is known that students like to have different kinds of digital technologies in the lectures and courses. On the one hand, they consider that a lecture is not updated if it is delivered without technology, even when more traditional subjects are addressed. On the other hand, if a lecture is totally based on technological artifacts, digital contents, and completely technology dependent, the students may think that the lecture is easy, trivial, and "*nothing to worry about,*" which usually leads to poor investment in studies and, ultimately, bad results and grades.

With tools like wikiLUA and the didactic market simulator, it was possible to understand that students feel more motivated with the use of digital technologies applications and resources, rather than the technologies by themselves. In fact, the results showed that students are interested in the use of information and computer technologies as tools to help them when they have learning difficulties.

Although these projects are still under development, the first results were encouraging. The main conclusions of the wikiLUA experiences are:

- When needing help in particular subjects, students usually like to do a self-search for tutorial resources or receive tutorial assistance in a more informal environment.

- Students feel more comfortable if they can access tutorial resources on the Web, since they can do it autonomously, in any place, taking any time, and whenever they want.
- Students manifested their interest in the availability of the tutorial support tool.
- The number of returning students, that is, the students who accessed the tools several times during the experience, can be considered to be a measure of the perceived usefulness of the tutorial support tool.
- Although there are no sufficient data to be conclusive, it is possible that the decreasing number of students requesting and attending orientation extra classes could be a consequence of the availability of Web tutorial resources.

Regarding the didactic market simulator, the main conclusions are:

- Some improvements were particularly noticeable, not only in classes as a whole but also with the succeeded students.
- It was very rewarding having practicing engineers sharing with students some of their professional experience in problems very similar to those that they were facing in the capstone project (a typical case of "situated learning").
- To play with a didactic market simulator in a typical telecommunication project proved to be extremely useful to integrate and consolidate previous learning, to help gaining a better understanding about businesses dynamics, and to improve teamwork skills.
- As compared to their company colleagues, test graduates exhibit better teamwork skills, show good ability to integrate and associate knowledge from different fields, and reveal good understanding of the telecommunication business markets.

The implementation of role-playing activities proved to be a fruitful pedagogical technique with the potential to transform theoretical concepts into experiential outcomes. In this way, educational role-plays engage students in close to real-world learning, providing opportunities for learning by doing, refining their understanding, and building new knowledge.

In the same way, the tutorial website proved to be a tool that students like to access and use, motivating them to be proactive agents of their learning processes.

Both methods analyzed in this chapter are useful tools for students' learning. However, each method has its own techniques, approaches, and goals.

The collected impressions of students showed that they prefer an informal learning environment and classes where they can practice subjects that were already formally taught in a formal classroom. With informal approaches to learning, students feel more relaxed and more capable to ask for help in the subjects where they feel more insecure. Our results encourage new research into stimulating learning at an individual and a group level and in different types of classes and syllabi.

Acknowledgments Some of the work reported in this chapter has been supported by an "HP Innovations on Education Grant." This support is deeply appreciated.

Thanks are also due to the following entities:

- Institute of Telecommunications for supporting the participation in CELDA of one of the authors
- Social Action Services of the University of Aveiro for supporting the grant of António Alves
- Fundação para a Ciência e Tecnologia for supporting the grant of Inês Direito

References

Anderson, J. R., Reder, L. M., & Simon, H. A. (1996). Situated learning and education. *Educational Researcher, 25,* 5–11. doi:10.3102/0013189X025004005.

Bates, A. W., & Poole, G. (2003). *Effective teaching with technology in higher education: Foundations for success*. Indianapolis: Jossey-Bass.

Bransford, J., Brown, A., & Cocking, R. (2000). *How people learn: Brain, mind, experience, and school, committee on developments in the science of learning*. Commission on behavioral and social sciences and education, National Research Council. Washington, DC: National Academy Press.

Carpio, J., Quejo, G., Guirado, R., Valcárcel, M., Simón, P., Santamaría, A., Fernández-Pérez, M. D. (2007). *Educational application of role-playing and simulation of professional environments related to the power systems and the electricity market*. Proceedings of the Meeting the Growing Demand for Engineers and Their Educators 2010–2020 International Summit, IEEE, Munich, Germany. doi: 10.1109/MGDETE.2007.4760380

Cooper, D., & Dougherty, R. (2001). Control station: An interactive simulator for process control education. *International Journal of Engineering Education, 17*(3), 276–287.

Direito, I., Pereira, A., & Duarte, M. O. (2010). Learning styles and autonomous engineering students: Na overview of theories, models and pedagogical implication. In M. Pedrosa-de-Jesus, C. Evans, Z. Charlesworth, & E. Cools (Eds.), *ELSIN XV, Exploring styles to enhance learning and teaching in diverse contexts. Proceedings of the 15th Annual Conference of the European Learning Styles Information Network* (pp. 162–165). Aveiro: University of de Aveiro.

Duarte, A. M. O., & Direito, I. (2009). *Vocational education and engineering enrollment: A case study*. Paper presented at the International Conference on Engineering Education & Research "ICEE/ICEER2009 KOREA", Seoul.

Duarte, M. O., Oliveira, I., Félix, H., Carrilho, D., Pereira, A., & Direito, I. (2011a). Active classrooms: Role-playing experience in telecommunications engineering education. *International Journal of Engineering Education, 27*(3), 604–609. (Special issue on "Learning through play in Engineering Education").

Duarte, O., Pereira, A., Castanheira, H., Lourtie, P., Gonçalves, I., Alves, A., et al. (2011b). *LUA-iNova—A new approach for tutorial assistance. Old meets new: Media in education*—Proceedings of the 61st International Council for Educational Media and the XIII International Symposium on Computers in Education (ICEM & SIIE'2011) Joint Conference (pp. 66–71). Aveiro: University of Aveiro.

Fedorov, A. (2007). *Media education: A historical perspective*. Moscow: Ministry of Education and Science of the Russian Federation.

Fournier-Viger, P., Nkambou, R., & Mayers, A. (2008). Evaluating spatial representation and skills in a simulator-based tutoring system. *IEEE Transactions on Learning Technologies, 1*(1), 63–74.

Furse, C. (2009). *No more lecturing in engineering!* Salt Lake City: University of Utah.

Gomboc, D., Lane, H. C., Core, M., Karnavat, A., Auerbach, D., & Rosenberg, M. (2008). *An intelligent tutoring framework for simulation-based training*. Proceedings of 16th International Conference on Computers in Education ICCE 2008, Taipei, Taiwan.

Kartam, N., & Al-Reshaid, K. (2002). Design and implementation of web-based multimedia techniques for construction education. *International Journal of Engineering Education, 18*(6), 682–696.

Kent, T. W., & McNergney, R. F. (1999). *Will technology really change education? From blackboard to web*. Thousand Oaks: Corwin.

Moore, W. (1968). *The tutorial system and its future*. New York: Pergamon.

Ozad, B. E., & Kutoglu, U. (2010 April). The use of the internet in media education. *TOJET: The Turkish Online Journal of Educational Technology, 9*(2), 245–255.

Palfreyman, D., Clark, J., Dawkins, R., Fox, R., Mash, R., Mirfield, P., et al. (2008). *The Oxford tutorial: 'Thanks, you taught me how to think'*. Oxford: OxCHEPS.

Smith, A. J., Collins, L. A., & Hannon, P. D. (2006). Embedding new entrepreneurship programmes in UK higher education institutions: Challenges and considerations. *Education & Training, 48*(8/9), 555–567. doi:10.1108/00400910610710001.

Stannard, R. (2009). *Video case study: Making tutorials with screen capture software*. Bristol: University of Bristol.

Vagos, P., Santos, L., Monteiro, S., Vasconcelos, G., Amaral, V., & Pereira, A. (2010). *Gestão do stress académico: Evidências do passado e desafios para o futuro*. I Congresso Nacional da RESAPES-AP. Apoio Psicológico no Ensino Superior: Modelo e Práticas (pp. 74–81). Aveiro: University of Aveiro.

Wales, T. (2008). Captivating open university students with online literature search tutorials created using screen capture software. *Program, 4*(42), 365–381.

Chapter 15
A Methodology for Organizing Virtual and Remote Laboratories

Panagiotis Zervas, Alexandros Kalamatianos, Eleftheria Tsourlidaki, Sofoklis Sotiriou and Demetrios G. Sampson

1 Introduction

During the past years, traditional laboratories have been significantly benefited by the technological advancements in the field of World Wide Web (de Jong et al. 2013, Balamuralithara and Woods 2009). This has enabled many educational institutions and scientific organizations to provide online access to state-of-the-art science experiments. This has been achieved via remote laboratories, which are based on actual experimental devices accessed remotely, as well as via virtual labo-

P. Zervas (✉)
Department of Digital Systems, University of Piraeus,
150 Androutsou Odyssea Street, GR-18532 Piraeus, Greece

Information Technologies Institute, Centre for Research and Technology—Hellas,
Thessaloniki, Greece
e-mail: pzervas@iti.gr

D. G. Sampson
Department of Digital Systems, University of Piraeus,
150 Androutsou Odyssea Street, GR-18532 Piraeus, Greece
e-mail: sampson@unipi.gr

Information Technologies Institute, Centre for Research and Technology—Hellas,
Thessaloniki, Greece
e-mail: sampson@iti.gr

A. Kalamatianos
Information Technologies Institute, Centre for Research and Technology—Hellas,
Thessaloniki, Greece
e-mail: alex.kalamatianos@gmail.com

E. Tsourlidaki
Ellinogermaniki Agogi, Dimitriou Panagea Str. 153 51 Pallini, Attikis, Greece
e-mail: Eleftheria@ea.gr

S. Sotiriou
Ellinogermaniki Agogi, Dimitriou Panagea Str. 153 51 Pallini, Attikis, Greece
e-mail: sotiriou@ea.gr

D. G. Sampson et al. (eds.), *Digital Systems for Open Access to Formal and Informal Learning,*
DOI 10.1007/978-3-319-02264-2_15,

ratories, which represent software simulations of science experiments (Gomes and Bogosyan 2009, Gravier et al. 2008).

Virtual and remote laboratories have been proved to be more effective in increasing students' interest in science and their engagement in related learning activities compared to traditional laboratories (Jaakkola et al. 2011, de Jong 2010, Kong et al. 2009). Additionally, the use of virtual and remote laboratories provides a significant number of benefits, which could be summarized below (Martinez et al. 2011, Gomes and García-Zubia 2007):

- Provides access to science experiments without location and time restrictions
- Supplements or even substitutes traditional laboratory assignments
- Facilitates better scheduling and execution of laboratory activities
- Offers significant return of investment in laboratory equipment due to laboratory devices sharing via remote laboratories
- Facilitates research collaborations between individuals and educational institutions or scientific organizations worldwide
- Supports autonomous learning, since students can use them and conduct experiments outside the formal borders of classroom teaching
- Supports students with disabilities to conduct experiments, when it is not possible for them to be present at the traditional laboratory

Virtual and remote laboratories that are currently available are promoted mainly by their owners and, thus, are scattered around the web. As a result, interested parties are facing difficulties in searching and retrieving them for further usage. A potential solution to this problem is the storage and organization of virtual and remote laboratories into web-based repositories (Li et al. 2007).

Within this context, a number of laboratory repositories have been recently developed aiming to provide interested parties with convenient access to existing remote and virtual laboratories (Richter et al. 2011, Maier and Niederstätter 2010). However, existing laboratory repositories are adopting different metadata models for characterizing their virtual and remote laboratories. To this end, this chapter aims: (a) to take stock of the current landscape of available repositories of virtual and remote laboratories and identify common metadata elements, (b) to propose a methodology for organizing virtual and remote laboratories by exploiting common metadata elements from existing repositories and (c) to introduce the concept of big ideas of science, as a complementary way of organizing virtual and remote laboratories based on fundamental ideas of the real world.

This chapter is structured as follows. Following this introduction, Sect. 15.2 reviews existing repositories of virtual and remote laboratories and performs a comparative analysis of the metadata elements used by these repositories towards identifying common metadata elements. Section 15.3 introduces the concept of the big ideas of science as a complementary way of organizing virtual and remote laboratories. Section 15.4 presents the proposed methodology for organizing virtual and remote laboratories in web-based repositories, which consists of the synthesis of common metadata elements identified in Sect. 15.2 and the set of big ideas of science identified in Sect. 15.3. Finally, we discuss our main conclusions and ideas for further work.

2 Review of Existing Repositories of Virtual and Remote Laboratories

2.1 Description of Existing Repositories of Virtual and Remote Laboratories

The aim of this section is to provide an overview of existing repositories of virtual and remote laboratories. A set of 13 repositories of virtual and remote laboratories have been assembled throughout research in related publications and Internet sources. Each repository has been visited and thoroughly analysed, according to the following dimensions:

- The types of laboratories included, namely virtual and/or remote laboratories, as well as the number of laboratories per category.
- The metadata elements used by each repository. These were classified in two categories: (a) laboratory owner metadata, which are added by the owners of a remote or virtual laboratory and (b) social metadata, which are added by the end users of virtual and remote laboratories and could include social tags, ratings and comments.
- The types of additional resources and apps connected to a remote or virtual laboratory. More precisely, the additional resources and apps were classified in three categories: (a) student's resources, which include resources that can be used by the students before, during or after the execution of an experiment with an online laboratory; (b) teacher's resources, which include resources that can be used by the teacher to design and develop learning activities supported by virtual and remote laboratories and (c) supportive apps, which include apps that can support students during the execution of an experiment with a remote or virtual laboratory.

Table 15.1 provides an overview of the existing repositories of virtual and remote laboratories which were analysed.

As shown in Table 15.1, the majority of the examined repositories include mainly virtual laboratories, whereas the number of remote laboratories included in these repositories is more limited. This is reasonable because remote laboratories are based on actual experimental devices, which might be very expensive and require high maintenance costs. On the other hand, virtual laboratories are computer programs, which can simulate a science experiment and they can be developed more easily. Finally, the total number of virtual and remote laboratories included in the examined repositories constitutes an adequate sample for our comparative analysis, which is presented in the next section.

Table 15.1 Overview of existing repositories of virtual and remote laboratories

No.	Name	Laboratory types		Number of laboratories		Number of laboratory owner metadata elements	Social metadata			Additional resources and apps		
		Virtual laboratories	Remote laboratories	Virtual laboratories	Remote laboratories		Tags	Ratings	Users' comments	Students' materials	Teachers' materials	Supportive apps
1	PhET[a]	√	–	125	–	10	No	No	No	No	Yes (lesson plan)	No
2	Library of Labs[b]	√	–	274	–	17	No	Yes (like ratings)	Yes	Yes (student's guide, assignment sheet)	Yes (lesson plan)	No
3	Labshare[c]	–	√	–	11	10	No	No	No	No	Yes (lesson plan)	No
4	Open Sources Physics[d]	√	–	100	–	13	No	Yes (1–5 star rating)	Yes	Yes (student's guide)	Yes (lesson plan)	No
5	Smart Science[e]	–	√	–	164	4	No	No	No	Yes (glossary, student's guide, tutorial)	Yes (lesson plan)	Yes
6	Molecular Workbench[f]	√	–	946	–	3	No	No	No	No	Yes (lesson plan)	Yes
7	Explore Learning[g]	√	–	450	–	6	No	No	No	Yes(assignment sheet, glossary)	Yes (lesson plan)	No
8	ChemCollective[h]	√	–	40	–	8	No	No	No	Yes (assignment sheet)	Yes (lesson plan)	No
9	Remotely Controlled Laboratories (RCL)[i]	–	√	–	17	4	No	No	No	Yes (student's guide)	Yes (lesson plan)	No

Table 15.1 (continued)

No.	Name	Laboratory types		Number of laboratories		Number of laboratory owner metadata elements	Social metadata			Additional resources and apps		
		Virtual laboratories	Remote laboratories	Virtual laboratories	Remote laboratories		Tags	Ratings	Users' comments	Students' materials	Teachers' materials	Supportive apps
10	Skoool[j]	√	–	4.950	–	5	No	No	No	Yes (assignment sheet)	Yes (lesson plan)	No
11	iLabCentral[k]	–	√	–	21	7	No	No	No	Yes (assignment sheet)	Yes (lesson plan)	No
12	Lab2Go[l]	√	√	157	51	13	No	Yes (1–5 star rating)	No	Yes (student's guide)	No	No
13	WebLab Deusto[m]	–	√	–	15	3	No	No	No	Yes (tutorial)	No	No
Total number of laboratories				7.042	279							

[a] http://phet.colorado.edu
[b] https://www.library-of-labs.org/
[c] http://www.labshare.edu.au/
[d] http://www.compadre.org/osp
[e] http://www.smartscience.net/
[f] http://mw.concord.org/
[g] http://www.explorelearning.com
[h] http://www.chemcollective.org/
[i] http://rcl-munich.informatik.unibw-muenchen.de
[j] http://skoool.com
[k] http://ilabcentral.org
[l] http://www.lab2go.net
[m] https://www.weblab.deusto.es/weblab/client/#page=home

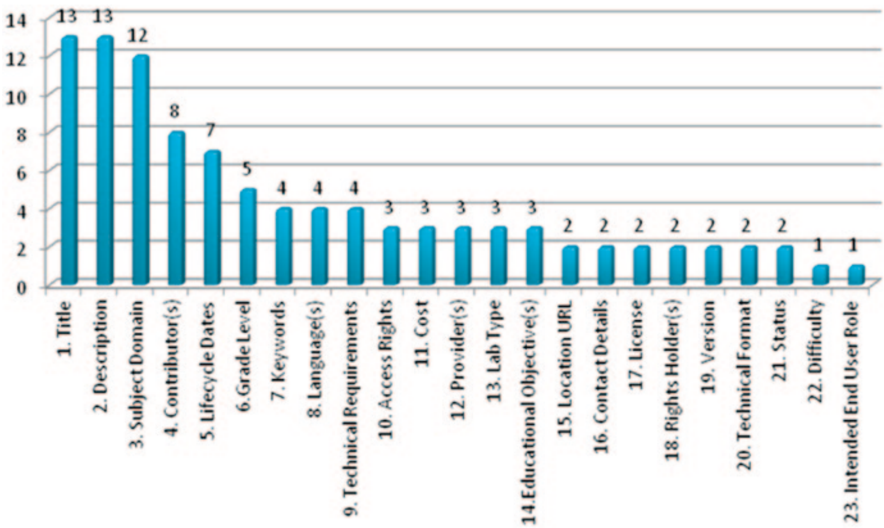


Fig. 15.1 Frequency of laboratory owner metadata elements used by existing repositories of virtual and remote laboratories

2.2 Comparative Analysis and Outcomes

The aim of this section is to perform a comparative analysis of the metadata elements used by existing repositories of virtual and remote laboratories.

Laboratory Owner Metadata

As shown in Table 15.1, each repository is using a different number of metadata elements for describing their virtual and/or remote laboratories. As a result, we harmonized the laboratory owner metadata elements used by the examined repositories, so as to produce a master list of laboratory owner metadata elements, as well as to identify frequently used metadata elements. Figure 15.1 presents the frequencies of the laboratory owner metadata elements.

As shown in Fig. 15.1, a master list of 23 laboratory owner metadata elements has been assembled. The most frequently used laboratory owner metadata elements, considering that they are used in more than 50 % of the examined repositories, are the following:

- *Title*: refers to the complete title of the laboratory (*13 occurrences*).
- *Description*: provides a textual description of the laboratory (*13 occurrences*).
- *Subject Domain*: refers to the laboratory's subject domain (e.g. physics, chemistry, biology, etc.; *12 occurrences*).

- *Contributor(s)*: refers to each person (or entity) that has contributed in the making of the laboratory in its current state (*eight occurrences*).
- *Lifecycle Date(s)*: refers to critical dates related to the laboratory's lifecycle (*seven occurrences*).

Most of these elements store general information about the laboratory except from the "subject domain" element, which stores information about the scientific discipline where the laboratory can be used. This means that existing repositories rarely use metadata elements that store information about the educational use of virtual and remote laboratories. Such metadata elements, according to the master list presented in Fig. 15.1, are the following:

- *Grade Level:* refers to the grade level for which the laboratory can be used (*five occurrences*).
- *Educational Objective(s)*: refers to the educational objectives that the laboratory addresses (*three occurrences*).
- *Difficulty*: refers to the level of difficulty of the laboratory (*one occurrence*).
- *Intended End User Role*: refers to the principal users for whom the laboratory was designed (*one occurrence*).

These elements can provide teachers with important information about the aforementioned educational aspects of the virtual and remote laboratories. However, they are not adequate to assist teachers in the process of designing meaningful learning activities using virtual and remote laboratories that will facilitate their students in understanding fundamental ideas of the real world. In order to address this issue, we introduce the concept of big ideas of science, as a complementary way for characterizing virtual and remote laboratories. This is further discussed in Sect. 15.3.

Social Metadata

As it is evident from Table 15.1, the majority of the examined repositories do not offer the opportunity to their end users (namely, teachers and learners) to participate in the characterization of virtual and remote laboratories. More specifically, concerning social tags, none of the examined repositories provide a social tagging system. Moreover, we can notice limited usage of users' comments and ratings. These options are offered by only three (23 %) of the examined repositories.

The overall absence of social tags and limited usage of users' comments and ratings to the examined repositories provide us with evidence that most of the repositories were developed on the basis of a sharp distinction between laboratory owners and end users. While the former are only responsible for the development and characterization of a virtual or remote laboratory, the latter are mostly assigned the role of a passive user. The limitation of this approach is that end users are given limited opportunities to provide their feedback and experiences about the use of virtual and remote laboratories that are stored in these repositories, and end-user interactions are not facilitated and creation of users' communities is not supported.

As a result, it is important to consider social metadata options, namely social tags, ratings and user's comments when organizing virtual and remote laboratories, as they could significantly facilitate the empowerment of the end users and their active participation and interaction with the these laboratories.

Additional Resources and Apps

As shown in Table 15.1, 10 (77 %) of the examined repositories offer student's materials, which are linked with the virtual or remote laboratories provided by these repositories. These materials include: (a) student's guides, (b) assignment sheets, (c) glossaries and (d) tutorials. Moreover, 11 (85 %) of the examined repositories offer teacher's materials, which are linked with the virtual or remote laboratories provided by these repositories. These materials mainly include lesson plans for exploiting virtual and remote laboratories in the context of learning activities to be conducted by their students. Finally, only two (15 %) of the examined repositories offer supportive apps that aim to facilitate students during the process of using a virtual or remote laboratory. However, these apps are very important, since they can facilitate students to formulate hypothesis or interact with experimental data.

As a result, it is important to consider additional resources and apps when organizing virtual and remote laboratories, as they could significantly facilitate teachers, when using virtual and remote laboratories for designing learning activities for their students, as well as students when using virtual and remote laboratories online in the context of these learning activities.

3 Big Ideas of Science: A Complementary Way for Organizing Virtual and Remote Laboratories

3.1 Definition

In order to help young students in learning science, there are several aspects teachers should take into consideration. One of those aspects is the fact that students appear to miss the connection between what they are being taught at school and the world around them. It is often the case that although students learn about fundamental principles, they fail to understand the connection between them as well as their connection to our life and to the world. These gaps in students' cognition often appear due to the fact that certain ideas are too abstract and thus difficult for them to grasp. Additionally, the fact that students often engage in several activities which are isolated and do not follow a meaningful sequence, which would allow them to build on the experience acquired by previous activities, acts as one more drawback to helping students understand the fundamental principles of our world.

Consequently, in order to succeed in helping students understand such fundamental ideas, it is necessary to create concrete learning experiences that are close to their everyday life and that are interconnected and presented within a common context. This way, students have the opportunity to build on them and ultimately develop a better understanding of fundamental principles by identifying the connections between different natural phenomena. The common context behind a set of learning episodes could be a fundamental concept that can be deployed to explain different phenomena under investigation. Such concepts are usually interdisciplinary and are often referred to as “Big Ideas” of science. Big ideas of science can enable learners as individuals to understand aspects of the world around them, both the natural environment and that created through application of science (Harlen 2010).

The term “Big Ideas of Science” has several similar definitions. For example, Harlen (2010) defines big ideas as “ideas that can be used to explain and make predictions about a range of related phenomena in the natural world”. The term “Big Idea” also refers to a statement that summarizes the core knowledge in a discipline that we would like students to understand (Wiggins and McTighe 1999).

In this chapter, we refer to “Big Ideas” as “a set of cross-cutting scientific concepts that describe the world around us and allow us to conceive the connection between different natural phenomena”. A “Big Idea” is a concept that connects different subject domains of science and is the common denominator of different natural phenomena. For example, the fact that “Objects can affect other objects at a distance” is the big idea behind the movement of celestial objects but also explains why magnets can attract iron objects. Thus, big ideas contribute in changing students’ view of science and allow them to learn coherent concepts rather than a set of disconnected concepts and facts.

3.2 Review of Existing Sets of Big Ideas of Science

Different sets of big ideas have been developed over time either for different domains of science or for science as a whole. One of the most popular sets of big ideas of science has been introduced by Harlen (2010) and is presented in Table 15.2.

The aforementioned set of big ideas concerns science education as a whole and covers multiple subject domains. However, other attempts have also been made in order to produce sets of big ideas on specific subjects. Such sets are presented in Tables 15.3, 15.4, 15.5 and 15.6.

3.3 Proposed Set of Big Ideas of Science

Our proposed set of big ideas of science is produced by adopting, combining and extending the existing sets while taking into consideration some adaptations that are presented below.

Table 15.2 Big ideas of science (Harlen 2010)

Number	Big idea
1	All material in the Universe is made of very small particles.
2	Objects can affect other objects at a distance.
3	Changing the movement of an object requires a net force to be acting on it.
4	The total amount of energy in the Universe is always the same but energy can be transformed when things change or are made to happen.
5	The composition of the Earth and its atmosphere and the processes occurring within them shape the Earth's surface and its climate.
6	The solar system is a very small part of one of billions of galaxies in the Universe.
7	Organisms are organized on a cellular basis.
8	Organisms require a supply of energy and materials for which they are often dependent on or in competition with other organisms.
9	Genetic information is passed down from one generation of organisms to another.
10	The diversity of organisms, living and extinct, is the result of evolution.

Table 15.3 Big ideas in physics (Denver Public Schools 2009)

Number	Big idea
1	Motion can be measured and described using a variety of methods
2	Forces and energy are essential to understanding motion
3	Collisions can be described using forces, energy and momentum
4	Energy and its conservation are essential in describing and analysing motion
5	The properties of sound and light demonstrate wave behaviour
6	Electricity is caused by the movement and energy transfer of electrons
7	Electric fields and magnetic fields are related and can be used for mechanical energy output (motor) or electrical energy generation (generator)
8	The nature of atoms cannot be directly observed but can be described through models

Table 15.4 Big ideas in chemistry (Talanquer 2013)

Number	Big idea
1	Atoms, molecules and ions are the basic components of matter
2	Chemical bonds are formed by electrostatic attractions between positively charged cores and negatively charged valence electrons
3	Atoms in molecules and crystals arrange in particular geometries
4	Atoms and molecules are in constant motion
5	Atoms in molecules and crystals can reorganize to form new molecules and crystals
6	Reactions occur when the disorder of the Universe is increased

One aspect that seems to be absent and needs to be introduced is that there are certain ideas like the universal application of fundamental principles that can be applied to all subject domains of science. Such an idea is even more generic than all the ideas presented above. Thus, it is important to have two distinct levels of big ideas. The first would be the "General Level" which will consist of big ideas that

Table 15.5 Big ideas in biology (Wood 2009)

Number	Big idea
1	Evolution as the basis for both the diversity and the unity of life
2	Biological systems and their properties, including energy use, molecular components, growth, reproduction and homeostasis
3	Information: how organisms store it, retrieve and use it, transmit and respond to it
4	Interaction of system components and the emergent properties of the resulting entities, from DNA molecules to cells to organisms to ecosystems

Table 15.6 Big ideas in Earth science (Ross and Duggan-Haas 2010)

Number	Big idea
1	The Earth is a system of systems
2	The flow of energy drives the cycling of matter
3	Life, including human life, influences and is influenced by the environment
4	Physical and chemical principles are unchanging and drive both gradual and rapid changes in the Earth system
5	To understand (deep) time and the scale of space, models and maps are necessary

are completely generic and apply to all fields of science. These general ideas will be broken down into more focused ones in the second level, the "Specific Level" that will reflect the principle ideas of our world and that to their total will cover all different subject domains of science. Conclusively, the big ideas of the general level are wider compared to those in the specific level. This set of ideas, as a whole, can be considered to be the background context for every single idea in the specific level. Respectively, every idea of the specific level targets particular concepts (e.g. evolution, energy, fundamental forces) while it is still a component of all of the ideas in the general level.

Additionally, by reviewing the sets of big ideas presented in Sect. 15.3, there is the possibility of merging a number of them into even bigger ones. Consequently, a part of our work focused on reviewing and comparing ideas from different or from within the same set that have similar meanings. This comparison led to the merging of some ideas and transforming them into bigger ones.

Another factor that we needed to consider was the fact that some ideas were in need of further elaboration so as to make them more complete and easier for learners to understand at various stages of their learning development. Thus, part of our work focused on further elaborating the existing big ideas so as to make them more complete. A more descriptive presentation of each big idea would also make them more comprehensible to students and allow them to identify connections between them more easily.

Overall, after reviewing the sets of big ideas presented in Sect. 15.3 and working on them based on the adaptations mentioned above, our proposed set is presented in Table 15.7.

4 The Proposed Methodology for Organizing Virtual and Remote Laboratories

This section presents our proposed methodology for organizing virtual and remote laboratories in web-based repositories, which consists of the synthesis of common metadata elements identified in Sect. 15.2 and the set of big ideas of science identified in Sect. 15.3.

4.1 Overview

The starting point for developing our proposed methodology was the outcomes derived from the review of existing repositories of virtual and remote laboratories performed in Sect. 15.2. From this analysis, we identified three dimensions, namely (a) laboratory owner metadata, (b) social metadata and (c) additional resources and apps.

Regarding laboratory owner metadata, a list of 23 laboratory owner metadata elements was compiled. Additionally, we consider one more laboratory owner metadata element that stores information about the proposed set of big ideas of science, as presented in Sect. 15.3. These elements have been divided into three categories, namely: (1) general metadata element, which stores general information about a virtual or remote laboratory; (2) pedagogical metadata element, which stores information about the educational use of a virtual or remote laboratory; and (3) technical metadata element, which stores technical requirements and characteristics for a virtual or remote laboratory. Regarding the social metadata, we identified three options. Finally, three options were considered regarding additional resources and apps that could be connected to a virtual or remote laboratory.

Figure 15.2 provides an overview of the proposed methodology, as well as the different categories and metadata elements per category.

In the next section, we provide detailed description of each metadata element, as well as controlled vocabularies and taxonomies for selected metadata elements.

4.2 Full Element Set

This section presents the full element set of the proposed methodology for organizing virtual and remote laboratories. For each element of the methodology, the following information is defined:

Table 15.7 Proposed set of big ideas of science

General level	Specific level
A. Physical and chemical principles are unchanging and drive both gradual and rapid changes in all systems throughout all scales of the Universe	Energy cannot be created or destroyed. It can only transform from one form to another. The transformation of energy can lead to a change of state or motion
B. The Universe and the world around us are not only composed of what we see around us. There are entities and phenomena that humans cannot grasp directly with their senses and yet they can be investigated and described using models and proper equipment	There are four fundamental interactions/forces in nature: gravitation, electromagnetism, strong nuclear and weak nuclear. All phenomena are due to the presence of one or more of these interactions. Forces act on objects and can act at a distance through a respective physical field causing a change in motion or in the state of matter
	The Universe is comprised of billions of galaxies, each of which contains billions of stars and other celestial objects. Earth is a very small part of the Universe
	All matter in the Universe is made of very small particles. They are in constant motion and the bonds between them are formed by interactions between them
	All matter and radiation exhibit both wave and particle properties
	Evolution is the basis for both the unity of life and the biodiversity of organisms (living and extinct). Organisms pass on genetic information from one generation to another
	Organisms are organized on a cellular basis and require a supply of energy and materials. All life forms on our planet are based on a common key component
	Earth is a system of systems which influences and is influenced by life on the planet. The processes occurring within this system shapes the climate and the surface of the planet

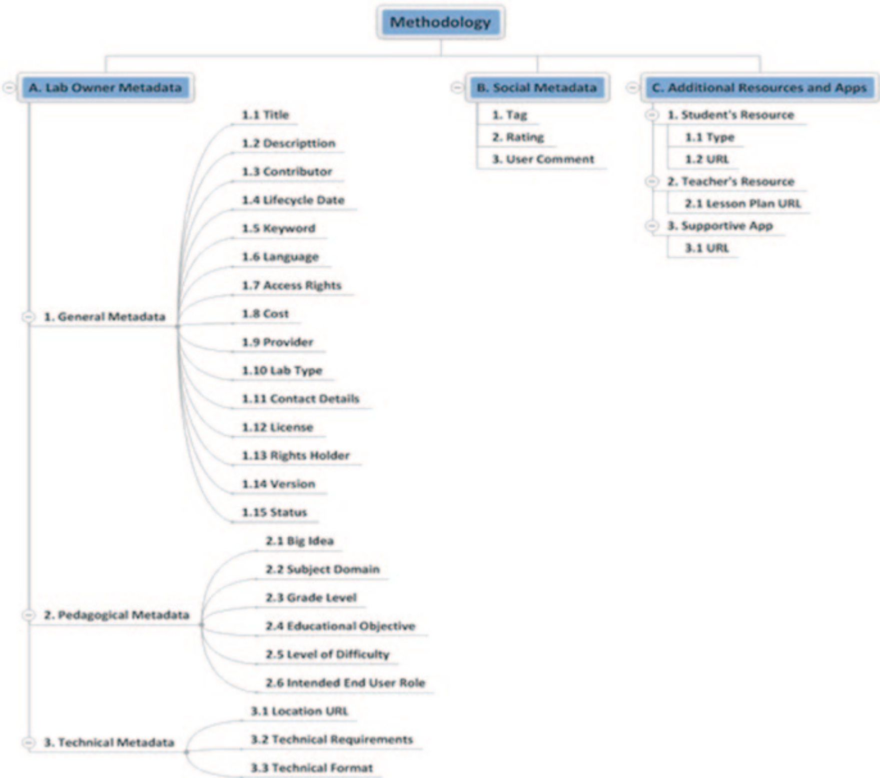


Fig. 15.2 Overview of the proposed methodology for organizing virtual and remote laboratories

- *Element Name*: the title of the element.
- *Description*: a short description explaining the information that the element can store.
- *Data type*: indicates whether the values of the element can be a character string or a vocabulary term.
- *Value Space*: the set of allowed values for the element. More precisely, the values could be in the form of (a) a vocabulary that has been compiled from the review of existing repositories of virtual and remote laboratories, as presented in Sect. 15.2 or (b) a reference to an external taxonomy (from previously published works or existing standards).

The first category of laboratory owner metadata includes 14 elements, as they are described in Table 15.8.

The second category of laboratory owner metadata includes six elements, as they are described in Table 15.9.

The third category of laboratory owner metadata includes three elements, as they are described in Table 15.10.

Table 15.8 Laboratory owner metadata: general category

Number	Element name	Description	Data type	Value space
A.1.1	Title	Refers to the complete title of the laboratory	Character string	N/A
A.1.2	Description	Provides a textual description of the laboratory	Character string	N/A
A.1.3	Contributor	Refers to each person (or entity) that has contributed in the making of the laboratory in its current state	Character string	N/A
A.1.4	Life cycle date	Refers to critical dates related to the laboratory's life cycle	Character string	N/A
A.1.5	Keyword	Refers to a set of terms that characterize the content of the laboratory	Character string	N/A
A.1.6	Language	Refers to the languages that the laboratory is available in	Vocabulary Term	Based on ISO 639-1[a]
A.1.7	Access rights	Refers to the laboratory's access permissions	Vocabulary Term	Open access Restricted access
A.1.8	Cost	Refers to any payment required for using the laboratory	Vocabulary Term	Yes No
A.1.9	Provider	Provides information about the provider of the laboratory	Character string	N/A
A.1.10	Laboratory type	Refers to the specific kind of the laboratory	Vocabulary Term	Virtual laboratory Remote laboratory
A.1.11	Contact details	Provides information about contact details of the person or the organization responsible for the laboratory	Character string	N/A
A.1.12	Licence	Provides information about copyrights and restrictions applied to the use of the laboratory	Vocabulary Term	CC –Zero (universal)[b] CC BY (v3.0 unported)[c] CC BY-SA[d] CC BY-NC[e]

Table 15.8 (continued)

Number	Element name	Description	Data type	Value space
				CC BY-NC-SA[f] CC BY-ND[g] CC BY-NC-ND[h] GNU General Public License[i] Commercial Other
A.1.13	Rights holder	Refers to those entities that hold the laboratory's copyrights	Character string	N/A
A.1.14	Version	Provides information about the current version of the laboratory	Character string	N/A
A.1.15	Status	Provides information about the availability status of the laboratory	Vocabulary term	Available Online Offline Unavailable

[a] http://www.iso.org/iso/catalogue_detail?csnumber=22109
[b] http://creativecommons.org/publicdomain/zero/1.0/
[c] http://creativecommons.org/licenses/by/3.0/
[d] http://creativecommons.org/licenses/by-sa/3.0/
[e] http://creativecommons.org/licenses/by-nc/3.0/
[f] http://creativecommons.org/licenses/by-nc-sa/2.0/
[g] http://creativecommons.org/licenses/by-nd/2.0
[h] http://creativecommons.org/licenses/by-nc-nd/1.0/
[i] http://www.gnu.org/licenses/gpl.html

Table 15.9 Laboratory owner metadata: pedagogical category

Number	Element name	Description	Data type	Value space
A.2.1	Big idea	Refers to the big ideas of science that the laboratory addresses	Vocabulary term	Taxonomy of big ideas of science as defined in Table 15.7
A.2.2	Subject domain	Refers to the laboratory's subject domain	Vocabulary term	Taxonomy of science curriculum terms as proposed in Sampson et al. (2011)
A.2.3	Grade level	Refers to the grade level for which the laboratory can be used	Vocabulary term	Primary education
				Lower secondary education
				Upper secondary education
				Higher education bachelor
				Higher education master
A.2.4	Educational objective	Refers to the educational objectives that the laboratory addresses	Vocabulary term	Taxonomy of educational objectives as proposed in Sampson et al. (2011)
A.2.5	Level of difficulty	Refers to the level of difficulty of the laboratory	Vocabulary term	Easy
				Medium
				Advanced
A.2.6	Intended end-user role	Refers to the principal users for whom the laboratory was designed	Vocabulary term	Learner
				Teacher
				Researcher
				Practitioner
				Administrator
				General public
				Parent
				Other

Table 15.10 Laboratory owner metadata: technical category

Number	Element name	Description	Data type	Value space	
A.3.1	Location URL	Provides a URL for accessing the laboratory	Character string	N/A	
A.3.2	Technical requirements	Refers to the technical requirements that are needed for using the laboratory	Vocabulary term	*Operating System*	Window
					MacOS
					Linux
					iOS
					Android
				Additional software	Java
					Adobe Flash Player
					LabView Runtime Engine
					Other
				Supported browsers	Mozilla Firefox
					Internet Explorer
					Google Chrome
					Safari
					Opera
					Other
A.3.3	Technical format	Refers to laboratory's technical format	Vocabulary term	Application/java	
				Application/x-shockwave-flash	
				Application/javascript	
				Application/widget	
				Application/zip	
				Application/xhtml + xml	
				Other	

Table 15.11 Social metadata

Number	Category	Description	Data type	Value space
B.1	Tag	Refers to a tag that characterize the content of the laboratory	Character string	N/A
B.2	Rating	Rating related to the quality of a laboratory	Vocabulary term	One star
				Two stars
				Three stars
				Four stars
				Five stars
B.3	User's comment	Textual comment including feedback from the use of a laboratory	Character string	N/A

Table 15.12 Additional resources and apps

Number	Category	Element	Description	Data type	Value space
C.1	Student's resource	C.1.1 Type	Refers to the type of student's resource that is connected to the laboratory	Vocabulary term	Student's guide
					Assignment sheet
					Glossary
					Tutorial
		C.1.2 URL	Provides the URL for accessing any student's resource that is connected to the laboratory	Character string	N/A
C.2	Teacher's resource	C.2.1 Lesson plan	Provides the URL for accessing any lesson plan that can be used for exploiting the laboratory	Character string	N/A
C.3	Supportive app	C.3.1. URL	Provides the URL for accessing any supportive app that are connected to the laboratory	Character string	N/A

The next dimension of the proposed methodology, namely social metadata, includes three categories, as they are described in Table 15.11.

The final dimension of the proposed methodology, namely additional resources and apps includes three categories, as they are described in Table 15.12.

5 Conclusions

Within the landscape of the mainstream use of virtual and remote laboratories in science education, it seems that there is not a common and educationally meaningful way for organizing virtual and remote laboratories via web-based repositories. As a result, this creates barriers to teachers, who want to search and retrieve virtual and remote laboratories for designing appropriate learning activities for their students. Thus, in this chapter we set the ground for a common methodology for organizing virtual and remote laboratories, which builds upon approaches from existing laboratory repositories and by incorporating the concept of big ideas of science.

It is worthy to mention that the results of this study are currently exploited by a major European Initiative referred to as: "Go-Lab—Global Online Science Labs for Inquiry Learning at School". The Go-Lab project (http://www.go-lab-project.eu/) aims to establish a federation of virtual and remote laboratories where laboratory owners can promote their laboratories and teachers can discover and use virtual and remote laboratories for designing meaningful learning activities for their students. More precisely, the Go-Lab project develops a repository, which follows the metadata elements of the methodology for organizing virtual and remote laboratories that is presented in this chapter.

Acknowledgments The work presented in this chapter has been partially funded by the European Union in the context of the Go-Lab project (Grant Agreement no. 317601) under the Information and Communication Technologies (ICT) theme of the 7th Framework Programme for R&D (FP7). This chapter does not represent the opinion of the European Union, and the European Union is not responsible for any use that might be made of its content.

References

Balamuralithara, B., & Woods, P. C. (2009). Virtual laboratories in engineering education: The simulation lab and remote lab. *Computer Applications in Engineering Education, 17*(1), 108–118.

de Jong, T., Linn, M. C., & Zacharia, Z. C. (2013). Physical and virtual laboratories in science and engineering education. *Science*, *340*(6130), 305–308.

de Jong, T. (2010). Technology supports for acquiring inquiry skills. In B. McGaw, E. Baker, & P. Peterson (Eds.), *International encyclopedia of education* (pp. 167–171). Oxford: Elsevier.

Denver Public School. (2009). Big Ideas in physics. http://curriculum.dpsk12.org/math_science/science/hs/physics/HS_Physics_BigIdeas.pdf. Accessed 30 Oct 2013.

Gomes, L., & Bogosyan, S. (2009). Current trends in remote laboratories. *IEEE Transactions on Industrial Electronics, 56*(12), 4744–4756.

Gomes, L., & García-Zubia, J. (Eds.) (2007). *Advances on remote laboratories and e-learning experiences*. University of Deusto. https://www.weblab.deusto.es/Advances_on_remote_labs.pdf. Accessed 30 Oct 2013.

Gravier, C., Fayolle, J., Bayard, B., Ates M., & Lardon, J. (2008). State of the art about remote laboratories paradigms—foundations of ongoing mutations. *International Journal of Online Engineering, 4*(1).

Harlen, W. (Ed.). (2010). *Principles and big ideas of science education*. Herts: Association for Science Education.

Jaakkola, T., Nurmi, S., & Veermans, K. (2011). A comparison of students' conceptual understanding of electric circuits in simulation only and simulation-laboratory contexts. *Journal of Research in Science Teaching, 48*(1), 71–93.

Kong, S. C., Yeung, Y. Y., & Wu, X. Q. (2009). An experience of teaching for learning by observation: Remote-controlled experiments on electrical circuits. *Computers and Education, 52*(3), 702–717.

Li, Y., Esche, S. K., & Chassapis, C. (2007). Classification of and search for online laboratory resources using a coding approach. In *Proceedings of the 37th ASEE/IEEE frontiers in education conference* (pp. F3G1–F3G6). Milwauke.

Maier, C., & Niederstätter, M. (2010). Lab2go—a repository to locate online laboratories. *International Journal of Online Engineering (iJOE), 6*(1), 12–17.

Martinez, G., Naranjo, F. L., Perez, A. L., Suero, M. I., & Pardo, P. J. (2011). Comparative study of the effectiveness of three learning environments: Hyper-realistic virtual simulations, traditional schematic simulations and traditional laboratory. *Physical Review Special Topics-Physics Education Research*, *7*(2), 020111-1–020111-12.

Richter, T., Boehringer, D., Jeschke, S. (2011). LiLa: A European project on networked experiments. In S. Jeschke, F. Isenhardt, & K. Henning (Eds.), Automation, communication and cybernetics in science and engineering (pp. 307–317). Heidelberg: Springer.

Ross, R. M., & Duggan-Haas, D. (2010). Big ideas in earth system science. *American Paleontologist, 18*(1), 24–28.

Sampson, D., Zervas, P., & Sotiriou, S. (2011). Science education resources supported with educational metadata: The case of the OpenScienceResources web repository. *Advanced Science Letters, 4*(11–12), 3353–3361.

Talanquer, V. (2013). Chemistry education: Ten facets to shape us. *Journal of Chemical Education, 90*(7), 832–838.

Wiggins, G., & McTighe, J. (1999). *Understanding by design*. Alexandria: Association for Supervision and Curriculum Development.

Wood, W. B. (2009). Revising the AP biology curriculum. *Science, 325*(5948), 1627–1628.

Chapter 16
Creative Collaboration in a 3D Virtual World: Conducting Educational Activities, Designing Environments, and Preserving Results

Mikhail Fominykh, Ekaterina Prasolova-Førland and Monica Divitini

1 Introduction

Establishing and nurturing vibrant and creative learning communities is a complex process (Wenger et al. 2002). Such communities are seen as highly important in developing and spreading new skills, insight, and innovation (Johnson 2010). The notion of a Community of Interest (CoI) incorporates the variety and dynamism that are typical features of a modern workplace (Fischer et al. 2007). According to Fischer (2005) and Fischer et al. (2007), CoIs have potential to be more innovative and transforming than a single Community of Practice if they can exploit "the symmetry of ignorance" for social creativity. Supporting social creativity across different domains and disciplines in learning communities is an important part of collaborative processes both in university education and in the context of large-scale international projects.

We argue that three-dimensional virtual worlds (3D VWs) can benefit creating and supporting learning communities. However, it requires a careful design that incorporates various activities and exploits advantages of the technology. 3D VWs are often seen as a type of social media, which are known for community support (Jina et al. 2010), and they have some unique features in addition (Molka-Danielsen 2011). They support synchronous interaction, providing a sense of presence, which is important for the development of online communities (Bronack et al. 2008). Many 3D VWs support user-generated content, allowing to leave traces of activities, which may become part of the shared repertoire of the community through reification (Wenger 1998). Wide opportunities for interaction and simulat-

M. Fominykh (✉) · E. Prasolova-Førland · M. Divitini
Program for learning with ICT, Norwegian University of Science and Technology,
Sem Sælands vei 7–9, NO-7491, Trondheim, Norway
e-mail: mikhail.fominykh@ntnu.no

E. Prasolova-Førland
e-mail: ekaterip@ntnu.no

M. Divitini
e-mail: divitini@idi.ntnu.no

D. G. Sampson et al. (eds.), *Digital Systems for Open Access to Formal and Informal Learning*, 257
DOI 10.1007/978-3-319-02264-2_16,

ing environments make 3D VWs suitable for conducting a range of virtual events, including meetings, performances, and role-playing (Sant 2009).

The above features of 3D VWs extend the possibilities of using boundary objects (Star 1989) and shared artifacts as catalysts of collaboration (Thompson 2005; Wenger 1998). Boundary objects are externalizations that have meaning across the boundaries of the individual knowledge systems or subcommunities and are necessary for overcoming distances in social creativity (Bruner 1996; Papert and Harel 1991b). Examples of such objects include "monuments" (symbols strengthening identity within the community), "instruments" (an infrastructure supporting interactive communication), and "points of focus" around which the collaboration is structured (Thompson 2005). In addition, online communities can benefit from such VW environments being dedicated community spaces (Wenger et al. 2002).

However, a collection of static or even interactive objects and environments do not provide a solid enough representation of community memory. Learning communities may carry and communicate part of their knowledge, both tacit and explicit, through collaborative activities, practices, relations, and experiences. Such fluid "knowledge containers" are difficult to capture and store in traditional repositories, but the knowledge they carry is essential for many high-skill professions. Drawing upon the work in activity theory (Engeström 1999; Leont'ev 1981), we may see *activity* as a primary source of knowledge development and distribution. Therefore, we focus on visualizing and crystallizing learning community activities.

We have earlier discussed and realized the idea to store community memory as a repository of virtual places that act as crystallization of memories of users and groups, their trajectories, culture and ecology within an organization/community, activities, and cooperation patterns, constituting the shared repertoire (Prasolova-Førland 2004). A typical example is a seminar room, with traces reflecting the presentations held there (e.g., agendas, slides, logos). Another example is a visualization of a student science project, containing traces of the students' collaborative constructive activities and elaborations of the ideas behind.

In this chapter, we explore alternative approaches to technology-enhanced learning, community building, and creativity support. We have chosen the Virtual Summer School as an innovative education form exploiting the strengths of 3D VW in both conducting collaborative activities and crystallizing their traces in a shared repository. The Second International Summer School on Collaborative Technologies, Serious Games, and Educational Visualizations was held in the Virtual Campus of the Norwegian University of Science and Technology (NTNU) in Second Life. The school was conducted in conjunction with the Cooperation Technology course at NTNU and organized by two research projects supported by the European Union (EU)—TARGET (http://www.reachyourtarget.org/) and CoCreat (http://www.cocreat.eu/).

Table 16.1 Creativity phases and Summer School activities

Creativity phase	Corresponding activities
Collect (searching for material and visualizing it)	Brainstorming the topic to be visualized Describing the design in group blogs
Relate (consulting with peers)	Participating in virtual events Exploring other constructions
Create (trying out solutions, creating associations, composing artifacts)	Collaborative construction Accessing building resources
Donate (disseminating results)	Role-play presentations Preserving constructions in the Virtual Gallery

2 Study Settings

In order to evaluate the effect of the Summer School on learning communities involved, we have conducted an exploratory case study. Educational activities of the study were systematically designed using a theoretical framework of collaborative creative process (Schneiderman 2002), as presented in Table 16.1.

2.1 Collaborative Educational Visualizations and Role-Plays

Collaborative educational visualizations and role-plays were conducted as part of the Summer School with 37 students working in ten groups, 3–4 students in each. The students were required to build an educational module representing a major curriculum topic and present it at a joint session by role-playing (Fig. 16.1).

We used pre- and post-questionnaires to identify the previous experience of the participants, their expectations of the forthcoming activities, and how the activities conducted matched their expectations. Each group was required to keep a blog for sharing and discussing proposals, reflecting and documenting the progress, and for the final discussion. In addition, each student was required to keep an individual blog for weekly reflection. The final presentations were attended, apart from the students, by representatives from EU projects and the general public. The resultant constructions have also been evaluated by students from the College of Education (COE), the University of Hawaii at Manoa (UHM). After the role-play session, each group saved its construction in a repository and evaluated the work of two other groups.

2.2 Supporting and Preserving Educational Visualizations

In order to assist students with constructing, presenting, and storing student 3D visualization projects, we designed a set of tools and places that we called Virtual Gallery (VG). It is designed based on the results of a case study we conducted earlier and serves mainly as a shared repository (Prasolova-Førland et al. 2010).

Fig. 16.1 Student visualization project Awareness Lab

The VG prototype was implemented, including a realistically reconstructed building (modeled after an existing student activity house on campus), a gallery for storing and presenting 3D constructions, and a library of premade 3D objects, scripts, textures, and links to other resources and virtual places (Fig. 16.2). The library of premade 3D objects, scripts, and textures could allow concentrating more on the creativity instead of technical details. In addition, student 3D visualizations occupied a considerable amount of space in our virtual campus in Second Life and there was a need for better storage solutions.

2.3 Virtual Events

Two international events were conducted as part of the Summer School. The first was organized as a seminar on EU projects, which included five presentations on relevant topics and a question-and-answer session. The objective of this event was to demonstrate to the students how international cooperation can be established and supported using modern technologies and to disseminate the results from TARGET, CoCreat, and other EU projects, exploring the possibilities for cooperation. The seminar took place in a formal lecture setting, with an amphitheater for the public, slide show, and interactive posters (Fig. 16.3). The event involved about 35 participants—presenters and the audience from several countries.

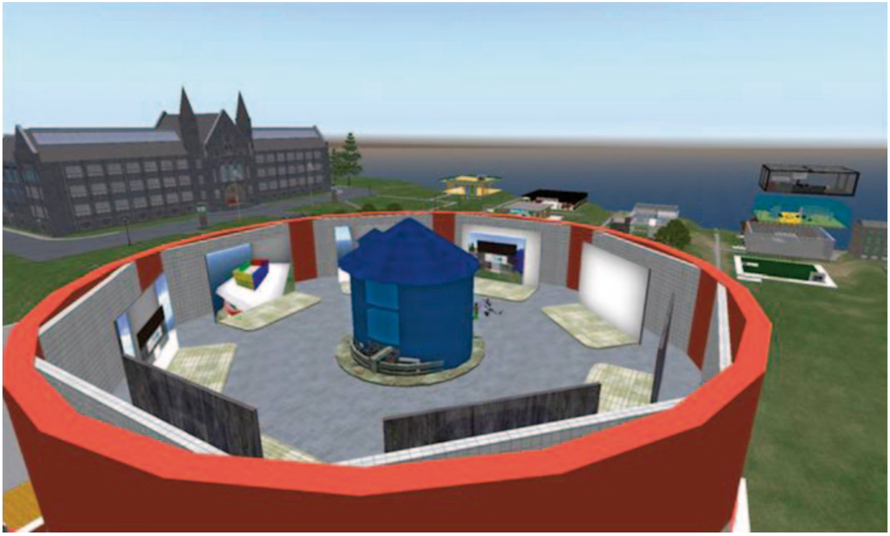


Fig. 16.2 Virtual Gallery prototype

Fig. 16.3 Virtual seminar at NTNU

The second event was organized as a virtual tour to the virtual campus of COE UHM and augmented with a feedback session with an invited expert. The students visited the major highlights of the COE UHM virtual campus. They were informed that the goals for the COE virtual campus are creating places for experimental teaching and research, socializing and collaboration, outreach, culture, and place for entrepreneurship. The visit was followed up by the return visit of the Hawaiian students. The goal of this exchange has been raising awareness of each other's research projects and seeding creative communities based on the joint interests.

2.4 Method and Data Collection

Our approach to using educational visualizations in 3D VW has been developed in several previous studies (Fominykh and Prasolova-Førland 2012). It is based on constructionism—an educational philosophy which implies that learning is more effective through building of personally meaningful artifacts than consuming information alone (Papert and Harel 1991a). Constructionism is related to social constructivism which proposes that learners co-construct their understanding together with their peers (Vygotsky 1978). In addition, we applied role-playing, which implies an active behavior in accordance with a specific role (Craciun 2010).

The data were collected from the direct observation of students' activities, pre- and post-questionnaires, virtual artifacts (chat log and 3D constructions), and user feedback in the form of blogs. For data analysis, we use the constant comparative method (Glaser 1965) that was originally developed for use in grounded theory methodology and is now applied more widely as a method of analysis in qualitative research.

3 Summary of the Study Results

3.1 Collect Phase

Brainstorming the Topic to be Visualized

For performing the visualization task of the Virtual Summer School, the students had the option of using both Second Life and other tools, both synchronous and asynchronous modes.

Six groups explicitly stated that the process of their project work was creative. In particular, four groups (including some of already mentioned) noted that they had a creative and productive idea generation process:

– *Generally, we are of the opinion that our construction process was somewhat more creative than in real life.*

Three of the groups noted that their creativity was not affected by the technology as they were brainstorming the constructions before starting to work in Second Life and designing on paper:

– *In the beginning, we spent time brainstorming about our project, at this point we ignored any technical limitations and decided that we would adapt our idea to these limitations when we started to build.*

Describing Construction Design in Group Blogs

The students were required to describe the design of the constructions in their group blogs to allow the ideas found during the brainstorming to crystallize. Reflecting on this task, they acknowledged its usefulness:

– Exploring and visualizing the topic textually through blogging had the advantage of allowing a more detailed description of the topic and about the functionality of the application.

Blogging technology was found useful at this stage of the project work by many groups. The students mentioned advantages of the technology 17 times, but the disadvantages only 5 times. Blogging was found to be easy, accessible, and simple. At the same time, it has low interactivity and weak support for synchronous activities, which, however, was found to be positive by some of the groups:

– Another upside is that your mental work will not be disrupted. That might be the number one advantage of avoiding instant communication. Disruptive communication may ruin your creative work when you focus on intensive thinking.

3.2 Relate Phase

Participating in Virtual Events

After the first virtual event, the students were asked to provide feedback to the seminar in their individual blogs, identifying both positive and negative aspects. Among the positive aspects, the following themes were mentioned most frequently (with the number of students discussing them):

- Geographical independence of the virtual meetings, allowing the attendance of participants from different EU projects and countries (15)
- The novelty and excitement when facing the technology and learning approaches “different from the normal kind of lectures” (5)
- The comfort of use both for the lecturer and the audience, including low threshold for asking questions and the flexibility of giving a talk from own office (8)

– The main advantage is that you can have lectures with both speakers and audience from all over the world. […] Also, comments and discussions with people from around the world might be completely different than what would result from an audience with just Norwegians.

Among the negative aspects, the following items were mentioned most frequently (with the number of students discussing them):

- Technical problems, especially with the sound, diminishing the overall educational experience (15)
- Attention distractions both inside (“unusual surroundings”) and outside the virtual environment (e.g., accessing social tools) and therefore difficulties with concentrating on the content (6)

– May be harder to keep focus during the presentation. Easier for the mind to slip when you're at the computer.

The analysis of the feedback from the *second virtual event* showed the different types of learning that occurred during the virtual tour. We identified 11 major themes. Those related to creativity and community support are (with the number of students discussing them) campus atmosphere (11), campus infrastructure (10), Hawaiian culture (11), sense of place and immersion (18), and places for informal learning (11). It was evident that the majority of the students felt an immersive Hawaiian sense of place. However, some students were not convinced by the immersive qualities of the environment:

– I did not feel "transported" to Hawaii as the whole concept of a 3d-simulation does not appeal very strongly to me, and I usually draw a very clear distinction between real life and a virtual imitation.

In the general feedback to both events, the students discussed the possibilities of 3D VWs for international collaboration and discussion, communication, promotion, corporate training, and emergency simulations:

– There might be some merit in using 3D virtual environments in creating communities across boundaries. […] we want to mention the potential of events; one-time happenings where one is able to gather around a common interest at a specified point in time and experience it together with other attendees.

However, the community building was understood as a long-term process that requires time:

– We could not really develop a bigger community based on our virtual events, because there was only very little time to communicate informally with other participants, but nevertheless they are vital for developing a community.

Exploring Other Constructions

We explored in what way the students were inspired by other constructions available in the virtual campus, including the constructions resulting from the First Virtual Summer School in 2010. The students expressed very different opinions from stressing the importance of studying previous students' constructions to mentioning a minor effect of this kind of studying for inexperienced users. Five groups stated that they were inspired by the available resources and examples of constructions:

– […] the student constructions can stimulate the community development by providing new ideas and inspire other people to create their own constructions.

The students discussed how resources and examples of similar projects available in the Virtual Campus affected their creativity. Only one student group stated that their creativity was positively affected by the resources and other constructions in the Virtual Campus. The other groups were to different degrees certain that their creativity was not affected:

– We looked at the earlier projects to get a feeling of what is possible of achieving in the given time for the project. Of course, our building was a bit inspired of the style of building […].

3.3 Create Phase

Collaborative Construction

The students applied different metaphors and design approaches that can be sorted into three main categories. They are "scenes for their role-plays" (purposes were too unclear without the presentations), "facilities" (workplaces, which visitors could use; games, where they could play; or tools, where a single user could learn), and "museums" (exhibition and guided tour instead of the role-play).

Half of the groups stated that 3D VW positively affects creativity and supports generation of new ideas:

– New ideas were often generated by "playing around" with objects without a concrete plan of what we wanted to achieve but by combining elements (prims) which we liked into a greater construct.

At the same time, the other groups argued that the technology, being unknown, hinders creativity:

– It affected our creativity in that manner that neither of us had any experience […]. So when we were supposed to start building, we did not know what was possible, and how to do the things that were possible.

Accessing Building Resources

The building resources available in the Virtual Campus were used to a limited degree. Most of the groups did not see them contributing to the community support. However, three groups explicitly mentioned these resources ease the constructing process:

– We discovered elements from other projects and generally around in second life that we wanted to incorporate into our [project]. Other things gave us inspiration to try to make ourselves or improve […].

– The amount of previous constructions was small, but it still showed what could be done, and what to aim for. Especially the latter might be inhibiting to creativity, as it might not be especially motivating to surpass the previously created work […]. The already available scripts and textures made building cheap, although it might lock participant into a narrow thought process […].

3.4 Donate Phase

Role-Play Presentations

During the final phase of the Summer School, the students were presenting their constructions to other participants. In the discussions, all the groups noted advantages of role-playing as a learning activity. The most popular of them include efficiency and safety compared to the real-life training, possibility to have a good contact with the audience, and offering experience together with information:

– 3D role-plays can be useful and sometimes necessary for imitations of real-life situations that can be dangerous, or that can happen (but still useful) with some lesser probability.

The students identified the two most serious challenges for such a type of activity: not enough realistic experience and the amount of effort required to make a play. Half of the groups discussed these challenges:

– […] even though we are presenting something based on a role-play we are still in a virtual environment. We think that it is not the same having a role-play in virtual environment or in real life.

Role-playing activity was also found to be an important part of the visualizations. In some cases, they clarified the purpose of static constructions. In some other cases, role-playing became the central part of the projects, while 3D constructions were serving as a stage.

Preserving Constructions in the VG

The students acknowledged the possibilities of 3D VWs for international collaboration, virtual visits, and knowledge sharing as it was done in the Summer School events. Virtual Campus of NTNU and generally 3D VWs were talked about as suitable for supporting communities in the long term.

Sharing 3D constructions received a positive feedback. Most of the groups stressed the importance of studying previous students' constructions to have inspiration. Some of the groups stated also that they get additional motivation from exhibiting their construction for other people:

– Sharing and exhibiting constructions in the Virtual Gallery is good because it can help newcomers introduce what 3D VWs […] are capable of, what is possible to do, what types of collaboration are possible.

However, a number of strong limitations were identified, such as low accessibility, technical problems, and that experience is not realistic enough:

– The "general public" uses small computers, mobiles and other platforms that don't have the power to run 3D VWs […]. That's more barriers added to the task.

4 Retrieving Crystallized Knowledge from Educational Visualizations

During three autumn semesters (in 2009, 2010, and 2011), three generations of Cooperation Technology students created 3D visualizations and role-plays as one of their course assignments. Most of their projects are preserved in our Second Life virtual campus and in the VG. Students who worked on the projects in 2010 and, especially, in 2011 provided a positive feedback on the gallery of 3D visualizations that had been created earlier. However, they mainly emphasized the possibility of having examples and learning different visualization methods and techniques. The students extracted the knowledge embedded into the 3D visualizations when trying to understand how it was represented with space, objects, and interaction.

We further explored the possibility of extracting knowledge crystallized in 3D visualizations towards the end of the visualization project in 2011. We invited a group of postgraduate students from COE UHM to visit our virtual campus to analyze and review the 3D visualizations created by our students. Apart from a few other aspects, we asked to describe how understandable the topic presented is and how informative the construction is. In order to complete such a task, the students had to try extracting as much knowledge crystallized in the 3D constructions as possible. It should be noted that the COE UHM students did not attend the role-playing presentations of the 3D constructions.

The results were the following. In five out of ten constructions, the main topics were easily identified by the COE UHM students. Four of these constructions were found informative, although with the limited number of learning objects. In three other constructions, the topics were found to be vague or too dependent on the observer. One of these constructions was described as informative. In the remaining two construction projects, the students failed to understand the topic. Most of the elements in both of them were found confusing.

In 2013, we continued exploring the possibilities for retrieving knowledge crystallized in 3D visualizations and activities conducted there. This year, our students of the same course (renamed to Cooperation Technology and Social Media) were given a different task—designing an educational game about one of the course concepts. However, we conducted an activity in our virtual campus, exploring and discussing the 3D visualizations made in 2011 and representing the core course concepts. Each group was assigned to one construction that they had to explore, try to understand which course topic it visualizes, and propose a game concept for it. After that, we went through 3D constructions all together and discussed the topics visualized and ideas of the game concept. The task was not easy for almost half of the student groups. However, the groups were able to identify all the topics (in some cases with the help of other groups) and suggest ideas for games that could be designed using these 3D constructions.

The feedback from this activity was collected by a questionnaire and individually. The data show that 44 % of the students found the topics and ideas behind the constructions clear, while 33 % found them vague. At the same time, 11 % of the students stated that the topics became clear after discussing the constructions with peers and the teacher.

We also found that 44 % of the students consider that the 3D visualizations are informative, but the educational content they present is limited. Some students (27 %) considered that more than half of the visualizations are informative, and 22 % voted that less than half are informative. When the students were suggested to answer how such visualizations could be reused, 56 % were not sure and 39 % could think of reusing them to some extent.

5 Summer School Summary

The objective of Virtual Summer School was to explore learning environments by inviting participants into practices where knowledge and insight are emergent from the diversity of the contributions. The virtual format of the Summer School demonstrated the possibilities of modern educational technologies for working and learning. It was a deliberate choice to organize the Summer School and the corresponding environment in accordance with the four phases of creative collaborative process by Schneiderman.

Based on our experiences, we can outline the following general implications for the use of the major elements of the virtual summer school:

- 3D visualizations are important for community building and dissemination of educational content, supporting exchange of ideas in a virtual workplace as well as enhancing creativity across boundaries of different CoIs. Therefore, there is a need to explore alternative and innovative ways of visualizing, storing, and managing community knowledge.
- 3D visualizations provide alternative possibilities for teaching and presenting innovative concepts and research results in an easy-to-understand way. These possibilities should be further explored.
- Virtual events are an integral part of the educational process and, therefore, of the Summer School organization and planning. We have explored different types of events and corresponding modes of learning. In order to facilitate such events and different learning modes, it is necessary to provide both social and educational spaces for community building and collaborative creative activities.
- Role-playing in 3D VWs constitutes a powerful disseminating tool and an integral part of the collaborative creative process. Role-plays can also serve as workplace training for students (as identified by their feedback). Therefore, a further exploration of the potentials of role-playing and serious games for supporting learning at the workplace is recommended.
- All the mentioned elements, i.e., 3D visualizations, associated role-plays, and virtual events, are interconnected, supplementary to each other, and necessary for creative communities support. For example, without the role-plays, the knowledge embedded into the constructions during the creative process was not fully retrievable. The 3D visualizations served as boundary objects and were, therefore, necessary to create a joint understanding between different CoIs.

6 Implications

In this section, we present the main implications derived from analyzing the data collected during the Virtual Summer School and the follow-up events. We focus on our lessons learned from conducting creative activities in the course of the Summer

School, supporting these activities by the features of the 3D environment, and retrieving the knowledge from the visualizations and activities held around them.

6.1 Conducting Creative Activities in the Course of the Virtual Summer School

In the following, we discuss how the activities in the different phases contributed to seeding and nurturing creative communities as well as how the existing Summer School facilities supported these activities:

- *Collect phase:* Brainstorming the topic to be visualized and discussing the design in group blogs contributed to establishing an initial domain, engaging issues, insights, and practices for learning communities. A set of resources in the Summer Schools such as existing student construction, tutorials, and joint feedback sessions in Second Life as well as feedback to the blogs provided initial motivation and facilitation for collaboration and brainstorming in blogs and other arenas.
- *Relate phase:* Participating in virtual events and exploring other constructions contributed to establishing new connections and multimembership in learning communities involved. These processes were supported in the Virtual Summer School by providing boundary objects to enable dialog and collaboration between learners from diverse backgrounds and disciplines (such as exhibition booths and slides from different projects) and by supporting a flexible infrastructure, enabling both formal and informal meeting and workplaces for members of different creative communities.
- *Create phase:* Collaborative construction of 3D visualizations contributed to unleashing and supporting social creativity in the participating communities during the Create phase, establishing a joint practice and trying out different solutions. This process was supported and motivated by the possibility of accessing building resources in the Summer School, both student constructions from earlier generations and various building tools and facilities.
- *Donate phase:* Presenting the 3D constructions with the role-plays contributed to disseminating the results from the participants and projects involved and enriching the reflective dialog in the communities with innovative expression forms. In addition, the visualized results are available 24/7 in Second Life as a part of the VG, thus constituting a shared repository of community knowledge. These activities have been supported in the Summer School by providing seminars on role-playing in a workplace context as well as storage and retrieval facilities for 3D content.

6.2 Supporting Creative Activities by the Features of the Environment

The Virtual Summer School we describe in this chapter was the second in a series of similar events. The first summer school was also held in our virtual campus in Second Life. However, for the second school, we improved the environment based on the results of the first school and a study on supporting creative communities conducted earlier (Fominykh et al. 2011).

The structure of the requirements is based on our previous research into collaborative work with 3D content (Fominykh and Prasolova-Førland 2011) and was evaluated during the first summer school. The virtual environment was developed on three levels, content, service, and community, as shortly outlined below:

- *Content level* (basic tools and methods for facilitating 3D construction process and elaborating on 3D content in VWs)
- *Service level* (tools and facilities for supporting collaborative educational activities in 3D VWs)
- *Community level* (methods and tools for creating and maintaining learning communities around educational activities in 3D VWs)

As we focused on collaborative creativity in the Second Virtual Summer School, we emphasized the support for the four phases of the creative collaborative process (Schneiderman 2002) in the set of our lessons learned from supporting creative activities with the features of the environment.

- Content level:
  - To facilitate the *Collect* phase of the creative collaborative process, it is necessary to provide similar projects or examples from previous student generations. A library of premade objects and tools assists learners with searching for material and visualizing it.
  - To facilitate the *Create* phase of the creative collaborative process, the environment should provide basic and advanced tutorials and a workplace, allowing the participants to try out different solutions, with minimized time/effort investment and a required degree of flexibility, in collaboration with peers.
  - To facilitate creation and appropriate use of virtual objects and media of different kinds, the environment should provide explicit examples of their use for presenting different types of information. In addition, it is necessary to provide explicit explanation and examples of content presentation forms, including the use of decoration and aesthetics, functionality, visual symbols, metaphors, and space organization. A set of tools and/or examples for supporting the development of dynamic content and interactive elements benefits the visualization process.
- Service level:
  - The environment should provide basic and advanced (specific domain oriented) tutorials, always available at hand. Additional materials and links to

external resources related to the activity or the topic being discussed should be provided.
- The environment should provide basic building resources, allowing the participants to start composing structures from ready-to-use blocks at an early stage.

• Community level:

- Collaborative facilities, such as seminar rooms, community spaces, and annotation and feedback facilities, should be available to provide support for consultations with peers and experts/visitors during the *Relate* phase of the collaborative creative process.
- Community repository (VG) should be available to allow learners to share and disseminate their projects, supporting the *Donate* phase of the collaborative creative process and exhibiting the results of the community activities through the process of reification (Wenger et al. 2002).
- The environment should support "creative communities," taking advantage of the mutual "symmetry of ignorance" (Fischer 2000; Rittel 1984), allowing social creativity to be unleashed at the boundaries of different domains. This can be realized by providing dedicated community spaces, such as group rooms and meeting places with corresponding initial community events (tutorials, discussions, and seminars). In these spaces, connections between different communities can be supported, such as students and teachers, external experts, and the general public by facilitating a series of community events.
- Initial boundary objects should be created, providing shared understanding and vocabulary among community members in the situation of "symmetry of ignorance" (Fischer 2000; Rittel 1984). Shared artifacts should be introduced as catalysts of collaboration, such as an infrastructure supporting interactive communication and "points of focus" around which the interaction and collaboration will be structured (Thompson 2005). The environment should comprise ideas, insights, and practices that are to be shared in the community at the early phase.

6.3 Crystallizing and Reusing Virtual Summer School Activities

Exploring the possibilities of 3D VWs for supporting community memory and experimenting with the VG, we discovered that knowledge can in fact be retrieved from both visualizations and traces of the activities held around them. In this section, we discuss the results of the two Summer School follow-up activities (presented in Sect. 4), in which we studied the knowledge retrieval process. In both activities, the participants were trying to retrieve knowledge from constructions without seeing the role-playing presentations of these constructions.

The visiting COE UHM students could easily see the topics presented and the purpose of half of the constructions. We consider this result as an argument for the possibility of knowledge retrieval, as those constructions that COE UHM students considered ambiguous or vague were created as “scenes for role-plays” or “facilities” (see Sect. 3.3.1). At the same time, it was very easy to extract the knowledge from the constructions of the “museum” type.

Discussing game design ideas using the 3D visualizations with Cooperation Technology and Social Media students can be seen as both retrieving knowledge from constructions (understanding what they are representing) and investing them with new activities (proposing games that can be designed there). The feedback we collected about this activity demonstrates that the students were rather positive towards retrieving knowledge from 3D visualizations. However, it should be considered that students have different learning styles, and perceiving the visual information is naturally easier for some of them and harder for the others. In addition, the 3D visualizations were a new type of information for all the participants. Therefore, we can conclude that ideas and knowledge can be conveyed by 3D visualizations.

Most of the students have also reflected that the 3D visualizations being informative had limited educational content. This result confirms that the purpose of visualizing concepts in a 3D environment was rather to present less information, but vividly, engaging, and entertaining. Most of the students replied individually that they are not sure if 3D visualizations could be reused, but several suggestions were made during the live discussion. This fact stresses that this form representing information is new to the students, and further research is required to understand how to reuse 3D visualizations.

Our experiences show that crystallization of collaborative activities and 3D visualization enriched the reflective dialog in the communities with innovative expression forms and contributed to creation of a shared repository of community knowledge. In particular, findings suggest that 3D VWs allow storing community memory directly in the form of crystallized activities, something that allows grasping complex concepts and accessing tacit knowledge. The 3D virtual environments may thus be a valuable add-on and contribute to the educational repertoire. We consider these conclusions preliminary, as they are the results of exploratory studies and need to be further investigated.

7 Conclusions and Future Work

In this chapter, we have presented our experience from conducting the Virtual Summer School in Second Life as an attempt to provide a systematized support for creative communities in a multicultural, cross-disciplinary context. In this way, a virtual summer school could be thought of as a framework or a technique that provides support for community building, collaborative creativity, and idea dissemination. Based on the data we collected during the summer school and the follow-up events, we identified implications for conducting creative activities, supporting these activities by the features of the 3D environment, and retrieving the knowledge from them.

In addition, we identified several challenges both related to the fluid and diverse nature of creative communities and the technology, in particular Second Life. Although the latter was chosen for its general popularity and accessibility, the results will be relevant for other social VWs as long as they support collaborative co-construction.

In our future work, we will explore further the possibilities of 3D VWs for supporting creative communities, in terms of organizational forms for educational and social activities, virtual environment design, and retrieving knowledge created during such activities and crystallized in the environment.

Acknowledgments The work is conducted in collaboration with TARGET and CoCreat—projects supported by the European Commission. This publication reflects the views of the author only, and the Commission cannot be held responsible for any use which may be made of the information contained therein. The authors wish to thank participants from the EU projects as well as all the students from NTNU and COE UHM.

References

Bronack, S., Sanders, R., Cheney, A., Riedl, R., Tashner, J., & Matzen, N. (2008). Presence pedagogy: Teaching and learning in a 3D virtual immersive world. *International Journal of Teaching and Learning in Higher Education, 20*(1), 59–69.

Bruner, J. S. (1996). *The culture of education*. Cambridge: Harvard University Press.

Craciun, D. (2010). Role—playing as a creative method in science education. *Journal of Science and Arts, 1*(12), 175–182.

Engeström, Y. (1999). Activity theory and individual and social transformation. In Y. Engeström, R. Miettinen, & R.-L. Punamäki (Eds.), *Perspectives on activity theory* (pp. 19–38). Cambridge: Cambridge University Press.

Fischer, G. (2000). Social creativity, symmetry of ignorance and meta-design. *Knowledge-Based Systems Journal (Special Issue on Creativity & Cognition), 13*(7–8), 527–537.

Fischer, G. (2005). Distances and diversity: Sources for social creativity. Paper presented at the 5th Conference on Creativity & Cognition, London.

Fischer, G., Rohde, M., & Wulf, V. (2007). Community-based learning: The core competency of residential, research based universities. *International Journal for Computer-Supported Collaborative Learning, 2*(1), 9–40.

Fominykh, M., & Prasolova-Førland, E. (2011). Collaborative work on 3D content in virtual environments: Methodology and recommendations. Paper presented at the 5th International Conference e-Learning (EL), Rome, Italy.

Fominykh, M., & Prasolova-Førland, E. (2012). Collaborative work on 3D content in virtual environments: A methodology. *International Journal of Interactive Technology and Smart Education (ITSE), 9*(1), 33–45.

Fominykh, M., Prasolova-Førland, E., & Divitini, M. (2011). Constructing a 3D collaborative virtual environment for creativity support. Paper presented at the 16th World Conference on E-Learning in Corporate, Government, Healthcare & Higher Education (E-Learn), Honolulu, Hawaii.

Glaser, B. G. (1965). The constant comparative method of qualitative analysis. *Social Problems, 12*(4), 436–445.

Jina, L., Wenb, Z., & Goughc, N. (2010). Social virtual worlds for technology-enhanced learning on an augmented learning platform. *Learning, Media and Technology, 35*(2), 39–153.

Johnson, S. (2010). *Where good ideas come from: The natural history of innovation*. New York: Riverhead.
Leont'ev, A. N. (1981). *Problems of the development of the mind* (4 ed.). Moscow: Progress.
Molka-Danielsen, J. (2011). Exploring the role of virtual worlds in the evolution of a co-creation design culture. Paper presented at the 2nd Scandinavian Conference on Information Systems (SCIS), Springer, 3–15.
Papert, S., & Harel, I. (1991a). Situating constructionism. In S. Papert & I. Harel (Eds.), *Constructionism* (pp. 193–206). Westport: Ablex.
Papert, S., & Harel, I. (Eds.). (1991b). *Constructionism: Research reports and essays 1985–1990 by the epistemology and learning research group*. Norwood: Ablex.
Prasolova-Førland, E. (2004). A repository of virtual places as community memory: An experience of use. Paper presented at the SIGGRAPH International Conference on Virtual Reality Continuum and its Applications in Industry, Singapore.
Prasolova-Førland, E., Fominykh, M., & Wyeld, T. G. (2010). Virtual campus of NTNU as a place for 3D educational visualizations. Paper presented at the 1st Global Conference on Learning and Technology (Global Learn Asia Pacific), Penang, Malaysia.
Rittel, H. (1984). Second-generation design methods. In N. Cross (Ed.), *Developments in design methodology* (pp. 317–327). New York: Wiley.
Sant, T. (2009). Performance in second life: Some possibilities for learning and teaching. In J. Molka-Danielsen & M. Deutschmann(Eds.), *Learning and teaching in the virtual world of second life* (pp. 145–166). Trondheim: Tapir.
Schneiderman, B. (2002). Creativity support tools—establishing a framework of activities for creative work. *Communications of the ACM, 45*(10), 116–120.
Star, S. L. (1989). The structure of Ill-structured solutions: Boundary objects and heterogeneous distributed problem solving. In L. Gasser & M. N. Huhns (Eds.), *Distributed artificial intelligence* (pp. 37–54). San Mateo: Morgan Kaufmann.
Thompson, M. (2005). Structural and epistemic parameters in communities of practice. *Organization Science, 16*(2), 151–164.
Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes. Cambridge*. MA: Harvard University Press.
Wenger, E. (1998). *Communities of practice: Learning, meaning, and identity*. New York: Cambridge University Press.
Wenger, E., McDermott, R., & Snyder, W. (2002). *Cultivating communities of practice: A guide to managing knowledge*. Boston: Harvard Business School Press.

Chapter 17
Active Creation of Digital Games as Learning Tools

Alejandro Catala, Fernando Garcia-Sanjuan, Patricia Pons and Javier Jaen

1 Introduction

Children and teenagers have nowadays access to interactive digital media and software in many different forms by means of several types of devices. This continuous contact with technologies contributes to digital literacy and makes them advanced citizens in the digital age. As a consequence, these users will be the base of skilled users in the future who will be able to deal with more complex and advanced software than ever.

Digital media and software should be used as a help supporting learning in combination with traditional materials rather than using the software as an exclusive means for learning, as reported in McFarlane et al. (2002) or as the pedagogical model elaborated in the work by Gros (2007) for formal learning settings. In particular, these authors involved commercial video games taking advantage of the knowledge that students already have on technologies as digital natives. Video games are useful in this respect because they also maintain both motivation and engagement usually high (Michael and Chen 2006), which is important for learning activities. In addition, they explain that using commercial video games instead of software to conduct specific tasks is advantageous for several reasons: They are cheaper than designing and ordering the development of specific digital serious games; and in spite of the low customization capabilities of commercial video games, given

A. Catala (✉) · F. G.-Sanjuan · P. Pons · J. Jaen
Grupo ISSI—DSIC, Universitat Politècnica de València,
Camí de Vera s/n, 46022 Valencia, Spain
e-mail: acatala@dsic.upv.es

F. G.-Sanjuan
e-mail: fegarcia@dsic.upv.es

P. Pons
e-mail: ppons@dsic.upv.es

J. Jaen
e-mail: fjaen@dsic.upv.es

D. G. Sampson et al. (eds.), *Digital Systems for Open Access to Formal and Informal Learning*, 275
DOI 10.1007/978-3-319-02264-2_17,

that the pedagogical model can slightly change with different teachers and learning subjects, the wider range of commercial video games available gives flexibility in the purpose of enriching the learning setting. All this means that teachers demand platforms that permit activity customization for the development of learning sessions rather than a video game to support already preestablished learning activities.

This vision is not essentially new, although video games had not been applied in a generic way for learning purposes until these studies in real classroom settings. Before the digital age, Clark Abt already wrote about serious games as tools for learning and the way they should be used (Abt 1970). Basically, he considered that games are useful tools for learning when they are played and consumed. However, his major contribution is the idea that they are more powerful when teachers and tutors consider playing to create games as the primary learning activity and involve students in the process. In his opinion, it is therefore more rewarding from a learning point of view because creating games entails design tasks, making up rules, and producing the materials and the logics behind the game to be created cooperatively rather than just understanding preestablished game rules. The perspectives illustrated above suggest that it will be more useful for teachers to have flexible digital tools available at hand that may be integrated in their respective pedagogical models for formal instruction, and that creative and social processes as the ones considered before the digital age along with higher motivation provided by the use of technology are of special interest for learning. Thus, a long-term goal would be providing a framework with these characteristics to be used in learning activities, so that teachers are able to create incomplete game ecosystems and design several creative learning exercises around them.

This chapter quickly reviews a collection of selected works which are focused on creating games with learning purposes. They represent the effort during the last decade and involve many different advanced interface technologies. To facilitate the discussion and analysis later, they are grouped in two sections. The first one deals with those proposals that have focused on supporting performances of preestablished characters or entities in a world ecosystem in a broad sense, by either programming or just performing with them to tell a story. Hence, the common feature for the works in this group is that users cannot create the characters or entities themselves but these are already preexisting and then users are allowed to perform with them or specify their behavior by encoding a program to tell a story. The second group is about those proposals that have considered the creation of characters/entities as a central task. Once characters are created, most of the works rely on a computational model to specify the behavior of these entities to build the simulation or the story. Finally, this chapter analyzes and shows how the creation support has varied over the years.

2 Creating Behavior in Preexisting Worlds

Since the programming language Logo and Graphics Turtle (Papert 1985) was devised as a way to show and teach computational concepts, many proposals have been inspired in a subset of the features of Logo, and many different technologies have been used to lower even more the cognitive effort (Kelleher and Pausch 2005), and have taken advantage of more appropriate interaction metaphors or any other human factor, such as social and collaboration skills. Two good examples are the following proposals based on the idea of using Logo in nonconventional ways to support computational thinking and learning.

The work by Suzuki and Kato (1995) describes AlgoBlock, which is an educational tool where users use physical block-like pieces that can be arranged all together to program the movement of a submarine within a labyrinth. Each physical block represents an instruction for the submarine (e.g., go forward, turn left, turn right, etc.). The result of the program execution is shown on a cathode ray tube (CRT) monitor by means of an animated submarine moving on a map. The system is primarily aimed at programming language learning by K–12 students. Moreover, it allows students to improve their skills in problem solving by means of some sort of collaborative programming tasks. By working with tangible tools, which can be shared in a collaborative workspace, AlgoBlock provides physical interaction and collaboration.

The second example is the work by Cockburn and Bryant (1998). Cleogo is a programming environment for groups based on the Logo programming language. It allows several users to collaborate in real time in the development of programs and check their execution. The users work with different personal computers that are interconnected through a network. Cleogo uses a graphical user interface based on WIMP to program the movement of the turtle in Logo. The aim is to encourage children to solve problems collaboratively. Each user has a screen equipped with a keyboard and mouse, but the input controllers provide access to all the functionality of a shared graphical interface displayed in the different screens. Although the system is limited in terms of numbers of users, a realistic limit is about four, to avoid degradation in system response and therefore user collaboration. Users can stay in the same room or in distant locations. In the latter, an audio channel of communication is needed to support voice interaction. The system does not provide any policy to avoid contradictory or conflicting actions by different users. This is left to social protocols rather than software mechanisms. Related to this, one aspect to be considered is the awareness of the actions among users. Telepointers are used to facilitate awareness. They are pointer representations in the screen that shadow the pointers of the other users. They play an important role in common communicational expressions such as "this" or "put it here," which normally requires gestural expressions to clarify the context of the statement.

Cleogo provides three different views following different programming paradigms. Users can use any of them as they prefer at any time. One is based on programming by demonstration following direct manipulation of the turtle. Another is an iconic language in which programs consist of a chain of instructions. The third is a textual language. Each language fits better for developing different user programming skills. The three views are kept consistently along the interaction.

Both previous works are relevant because one provides a tangible interface for the language and the other provides a multiuser networked approach. Although they support programming (i.e., creation of programs), the virtual objects and the world in the simulation are completely preestablished.

Fig. 17.1 TurTan running a tangible program. (Photography supplied courtesy of TurTan's authors)

A third outstanding example using Logo is the work by Gallardo et al. (2008). TurTan is a tangible programming language that uses a tangible surface interface in which tangible pieces represent virtual instructions of programs (see Fig. 17.1). As already mentioned, this is inspired by Logo, and, therefore, it was designed to generate geometries with a turtle. As in the original Logo language, one of the design objectives of TurTan is learning programming concepts. TurTan starts with a black screen with the image of a little turtle in the middle. When a tangible (i.e., instruction) is put down on the surface, a visual response is provided and the instruction is executed, applying the result on the turtle. The programs consist of a sequence of tangible instructions that have been put on the surface over time. The parameters of instructions can be set by rotating the tangibles. Touch input is integrated seamlessly with the use of tangibles for the real-time visualization of the program results as users collaborate in the program construction. The work does not report on user evaluation on either learning or creativity, although the authors do mention the necessity to explore these dimensions as the system is oriented towards young children.

Another relevant work is the exploration on tangibles carried out in Fernaeus and Tholander (2006) and Fernaeus et al. (2008). They discussed a system that allows children the creation, edition, and simulation of a two-dimensional (2D) virtual environment in a collaborative way. The TangibleSpaces system consists of a large carpet with an array, a set of plastic cards with radio frequency identification (RFID) tags representing entities and operations, and a screen which shows the state of the system under construction. The cards comprise a compositional tangible mechanism as input to the system to express entity behavior. Specialized card operators for the creation of entities are available. They allow children to collectively create the virtual world by inserting the creational card along with a card representing an entity in the physical array. Additional behaviors or property changes can then be performed by stacking other cards on the entity. These compositional constructions in the physical world have a representation in the virtual simulation displayed on the screen.

Fig. 17.2 Tern allows programming behavior of virtual entities and robots. (Photography supplied courtesy of Michael Horn)

Several issues that authors addressed are related with this duality representation in the physical setting and the virtual representation where the simulation is eventually carried out. These worlds could be seen from a mirror metaphor, so that actions in one world would affect the other in both ways. However, the carpet remains more like an input method since changes in the virtual simulation are not easily transferred to the physical setting (e.g., entity cards cannot be autonomously moved as a consequence of the evolution in the virtual simulation). This disparity is not intended as a limitation by the authors but they try to complement each representation as much as possible. For instance, it is possible to create a forest as a bunch of trees by using only a tree card along with a modifier card, instead of using many tree cards. In this way, the physical representation can be simple, suitable, and advantageous to several situations.

In contrast to the work by Fernaeus and Tholander, which was focused on tangible interaction to make up a 2D interactive world, the work by Horn and Jacob (2007) is more focused on designing tangible programming languages to specify the behavior of robotic ecosystems. Two tangible programming languages were presented, Quetzal and Tern. They use physical objects (plastic or wooden pieces) with no electronic device but with visual tags (see Fig. 17.2). Each piece represents a specific instruction and they can be connected to each other to build a program. These languages were designed to teach basic programming to children in a classroom setting in primary and secondary school. The main advantages are that they are made of durable low-cost components, with no connection required and fostering collaboration among children.

Both languages are compiled using a portable scanning station by using computer vision techniques, so that the program is captured and translated to intermediate languages that finally are compiled to code for the targeted platforms. In the case of Quetzal, LEGO Mindstorms robots can be controlled, whereas virtual robots moving in a 2D virtual world are involved in the case of Tern. In the case of syntax errors, the systems show the image of the program along with an arrow pointing towards the problematic piece. The robots can interact in the same world, and several student groups can collaborate to solve problems to pick up objects or navigate through a labyrinth. The teacher can easily add a projector to show the world array in a projection screen, allowing students to participate in a shared activity.

The work by Leitner et al. (2008, 2009) represents a great effort in joining tangible and interactive digital interfaces to foster creativity. IncreTable is a game based on The Incredible Machine that uses an advanced high-technology setting focusing on mixed-reality tabletops. The system is composed of an interactive tabletop equipped with digital pens, robots, and a depth camera that allows advanced interaction with actual three-dimensional (3D) objects. The game consists of several puzzle exercises that require the construction of Rube-Goldberg machines, involving virtual as well as actual domino pieces and other physical objects such as portals or robots. Levels are supposed to encourage user creativity to solve the puzzle in a complex way. Although the system allows users to freely create a specific arrangement of virtual and tangible elements to achieve the goal, these elements and the levels themselves are completely preestablished. A subsequent evaluation of the platform has explored the relationship of certain interaction aspects with this advanced technology with flow.

Finally, Kelleher and Pausch (2007) presented StoryTelling Alice. It is a programming environment aimed at teenage girls (11–15 years old) to encourage them to learn programming skills. This goal is motivated given the low rate of female students enrolled in computer science courses in the USA. This system allows novel programmers to create programs that control the movement of objects in a virtual 3D world. The girls can tell their stories in the virtual environment by means of programs, and so they require programming scenarios as well as the character behaviors to appear in the animations. The 3D world has a list of objects, with properties, methods, and functions, which the users select from a gallery of objects. A set of preestablished animations (e.g., move, turn, resize, etc.) can be applied to all these objects. Users can code their own procedures to specify behavior by selecting, dragging, and dropping the methods and the objects in the parameter gaps accordingly in a WIMP-based interface, as Fig. 17.3 shows. This way Alice facilitates the construction of programs free of syntax errors simply by drag&drop interaction techniques and, moreover, the tool provides a previsualization mode so that users can see the resulting animation in advance to check whether the instructions they encoded do what programmers wanted.

In this context, their work in Kelleher et al. (2007) reported a user-based study. It was carried out to compare learning, behavior, and the attitude of girls who start programming with Alice. A total of 88 girls, 12.6 years old on average, were involved in 4-h-long workshops. Forty-five girls used the generic version of Alice as a control group, and 43 used the StoryTelling Alice. The task consisted in completing a tutorial of the software and creating a program within 2 h and 15 min with the version of Alice they were assigned. After that, they tried the other version of Alice for 30 min. From the programs produced and the answers to questionnaires, the study concluded that girls were equally entertained and were successful in learning programming concepts using both versions of Alice. However, the girls using StoryTelling Alice showed more engagement with programming, spending more time with the software; they were more likely to use the software during some extra time, and showed a higher interest in using it in the future.

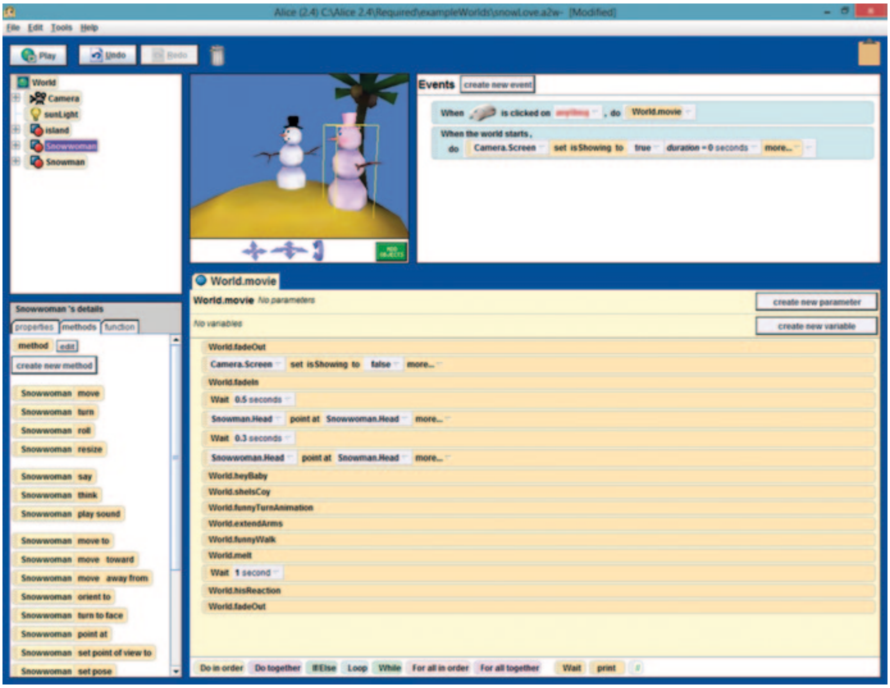


Fig. 17.3 Alice interface for programming. Screenshot of Alice 2.4, which is made freely available by Carnegie Mellon University

3 Creating Entities for Interactive Worlds

If the works in the previous subsection were primarily characterized by the use of preestablished entities to carry out a simulation or a performance in a variety of ways, the works in this subsection are mainly distinguished as they also give relevance to the creation of the entities.

Maloney et al. (2004) present Scratch. It is a graphical programming environment that allows children to program interactive stories, games, animations, and simulations. All these are based on 2D stages composed of a background and a set of sprite-based objects. The language used to specify behavior is based on Logo-Blocks (see below), so that users build programs by just dragging and dropping blocks representing instructions that match in shape to each other avoiding syntax errors. The main screen of the tool has a panel where the stage is shown, allowing program debugging and testing new ideas increasingly and iteratively (see Fig. 17.4). Although Scratch is a mono-user application based on WIMP interaction, there exists a web-based online community supporting the Resnick's Spiral (Resnick 2002), which aims to foster discussion and creativity between users, relaying on collaboration, mutual discussion and distributed contribution. However, all this has to be done outside Scratch itself. In Aragon et al. (2009), an empirical study is conducted, which explores the use of communications in distributed users using

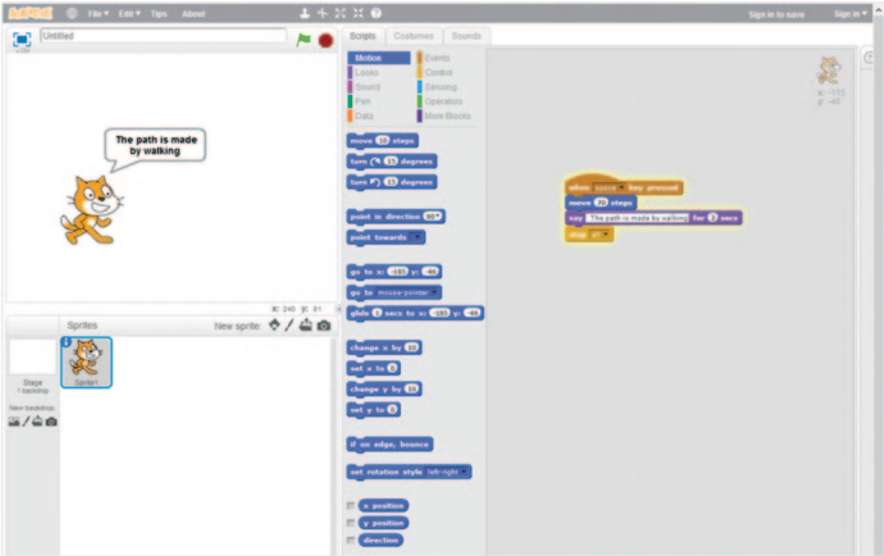


Fig. 17.4 Scratch environment. Screenshot of Scratch online (scratch.mit.edu) running in a web browser

Scratch for effective collaboration in creative work. The authors concluded that socio-emotional communication is important for successful creative work and emphasized that systems supporting social creativity must facilitate sharing and play.

LogoBlocks is a graphical programming language to support programming for the LEGO programmable brick (Begel 1996). The brick is a small computer that can be embedded and used in LEGO creations by reading from sensors and controlling engine activations. LogoBlocks is a graphical alternative to the former language BrickLogo. Instead of writing a program in text, users can now put several graphical blocks in the workspace so that they represent instructions of a program. Syntax errors are avoided by representing every instruction in the program with a block, and providing visual cues such as specific shapes matching with other blocks, and easily supporting block property exploration by means of double-clicking techniques.

Although visual programming as in LogoBlocks is advantageous for beginners, since it allows them to avoid syntax issues and see the program at a glance, several drawbacks are already mentioned in this work. For instance, advanced programmers can feel frustration since the textual language could represent more concisely some basic statements or common behaviors. In addition, the number of visual primitives present in the screen is usually more limited since icons and graphical representations require more space. Another problem is the difficulty to support extensibility of the languages, which usually are designed as sealed domain-specific languages.

LogoBlocks follows a drag&drop metaphor in a WIMP user interface. A palette on the left of the screen contains the different blocks available. They have different shapes and colors for the available block categories: The action blocks allow controlling engines and perform "wait" and "repeat" operations, the sensor blocks obtain information from the real world, variable blocks represent variables in the program that can be connected to other blocks requiring numbers, and procedural blocks provide an abstraction mechanism for the implementation of procedures. Although LogoBlocks itself is simply the graphical programming language, it is targeted at the programmable brick and therefore the constructions of the robots are creations that can be also used as part of an ecosystem.

Another relevant work with the idea of creating 2D entity-based virtual ecosystems in full is the one by Repenning (Repenning et al. 2000). AgentSheets is a tool based on agents that allows users to create simulations and 2D interactive games. These creations can be published as Java applets on the web. Users can create simulations of sprite-based agents in a 2D world based on a rectangular array. A cell in the array representing the world can contain any number of agents stacked which can directly be manipulated. The users are responsible for designing the visual aspect of agents by drawing icons. The behavior of agents is based on event-based rules. The rule editor follows a rewriting rule paradigm. The user expresses the conditions of the rule by selecting the visual state and the visual icon representing the event. The action to be performed is typically expressed as a postcondition, showing how the situation expressed in the precondition must be changed.

An innovative tangible approach is the one presented by Raffle et al. (2004). Topobo is a 3D constructive assembly system that allows the creation of biomorphic forms like animals and skeletons. This is achieved by means of pieces embedded with kinetic memory and the ability to record and playback physical motion. Topobo is designed to be a user interface that encourages creativity, discovery, and learning through active experimentation with the system. Studies with children and early adolescents are reported Parkes et al. (2008). In the case of teenagers, the study explores how the system supports design, concluding that Topobo can help students to learn about several educational concepts on physics such as balance, center of mass, coordination, and relative motion. Later, Topobo has been more extensively used in a range of different contexts for further evaluation. For example, it has been used in an extramural course for teenager students for 3 months for free activities; with children and young teenagers for 8 months targeted at object-oriented tasks in the context of sciences; or even in architecture courses with adult students, using Topobo for the design of their final project. In all these trials, the teachers considered Topobo as a useful or interesting tool, although they stated that training with the system is needed to be confident with it and show reliability in teaching.

ShadowStory is a storytelling system inspired by Chinese traditional shadow puppetry presented in Lu et al. (2011). Children use a tablet PC (a laptop with touch input) to create digital animated characters and other accessories or props, and then they are allowed to perform stories on a back-illuminated screen, controlling the characters with simple movements by means of orientation handheld sensors. Thus, ShadowStory includes two interaction modes. In the "design" mode, the elements for the story are created whereas in the "performance" mode the story is told to the public like in the traditional Chinese puppetries.

In the design phase, children use a tablet PC and its pen-based input to create three types of elements for the story: characters, props, and backdrops. To create a character, the system provides an articulated template consisting of head, chest, arms, and legs. These parts can be created individually using the knife and brush tools to cut and paint the parts. In addition, props or nonarticulated accessories to be used as well as the curtains can be created similarly with a range of digital tools. Besides creating all these elements, it is possible to pick predefined elements from an existing library.

Once all the elements have been designed, the story is almost ready to be performed by the children. First, the stage should be arranged according to the story along with the participation of the characters. Automatically, each character added to the stage enables a pair of wireless 3D orientation handheld sensors. Once all this is done, the performance can be activated and children can tell the story projecting the characters on a wall screen.

The work by Catala et al. (2012b) describes the implemented middleware to support a learning framework which relies on the vision of "playing to create games." It relies on a meta-model for physically based 2D entities that can be enacted according to physics principles and rule-based behavior. The system uses an interactive tabletop as ground technology for both authorship and play, which provides several advantages over other existing approaches. It not only keeps motivation in high levels but also encourages social participation and enables more natural interaction in collaborative tasks (Catala et al. 2011).

It focuses on the creation of several artifacts to create 2D game worlds. The activities can be oriented towards several core tasks. For example, the system can be used to create characters for storytelling purposes so that the surface is the stage and anchorage points for entities and gravity are defined so that entities resemble flattened puppets to perform the story. Another possible scenario can be focused on teaching essential physics by creating single entities as punctual masses aiming at some specific goal and then exploring how the world evolves (see Fig. 17.5).

There are also some limitations. On the one hand, the use of the tabletop is not for masses but intended for small groups, so that the discussion and interaction can be properly conducted from a pedagogical viewpoint. On the other hand, the type of game ecosystems is based only on 2D performances and simulations, leaving out more advanced interesting scenarios based on 3D concepts. Nevertheless, it is still a powerful tool for teachers as it allows them to create partial ecosystems for many different learning scenarios adapted to their needs.

The platform has been used in several creative assembling tasks in two experiments involving teenagers. Subjects faced problems such as creating articulated entities (2012a) and functional Rube-Goldberg machines (2012c). The activities were considered within a discussion–action–reflection loop so that students could create the proposals collaboratively and interact between them. The tests showed that tabletop technology maintains students' motivation, helps in sharing digital objects more effectively, and that the aforementioned loop facilitates fairer cooperation interaction patterns, which are positive in terms of social skills development.

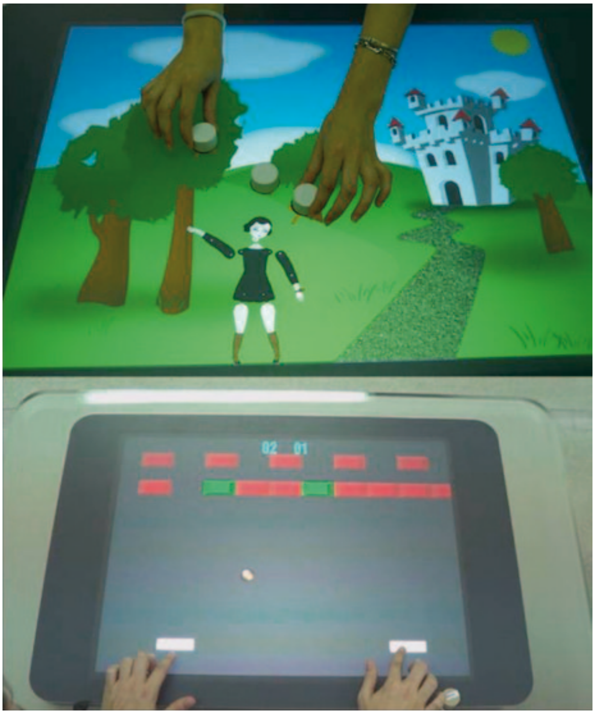


Fig. 17.5 AGORAS running games created by users

4 Technological Analysis

With the aim of providing a detailed analysis of the sample works briefly described above, several features are presented next. We have considered this set of features relevant because they can be useful to compare proposals with regard to several characteristics related to the ideas and requirements associated to seminal Abt's ideas.

Firstly, we consider some general features. The "Primary aim" feature indicates the primary function and aim of the proposal or system. For instance, a system could be created to support the learning of computational concepts, for social learning purposes, or simply for entertainment, etc. To simplify the classification, avoiding unnecessary complexity, only two broad categories have been considered: learning purposes (L) and entertainment (E).

The "Target users" feature refers to the users that the system is aimed at. The "Study" feature indicates whether the proposal reported some kind of user experience, or any user-based evaluation, study, or experiment. In addition to developing a proposal according to cognitive and/or social theories, it is highly interesting to evaluate them and validate that the main assumptions are achieved by the built prototype.

“Social interaction” indicates how users interact with each other within the system. Typically, systems supporting some kind of social interaction achieve this by putting users in a co-located setting (C) or in networked different places (N). Co-location allows for face-to-face communication whereas networking allows chatting or audio–video communication. Social interaction could be focused on competition or collaboration. As most of the proposals are about learning purposes, they normally focus on collaboration processes. A system can be used alone, not supporting any social interaction, although putting users to discuss ideas in front of a shared single computer could provide some sort of social interaction anyway.

Additionally, we have considered some attributes that describe how the simulation or performance is carried out. Firstly, the “Ecosystem Type” indicates the type of ecosystem involved in the proposal. Normally, the ecosystems consist of a set of entities represented in a range of ways across the systems. It has been shown in the description of the related work how they can be represented by 2D single sprites, 2D virtual complex shapes, single or complex tangibles, robots, 3D digital complex objects, etc.

Secondly, the “Behavior specification” informs about the inherent model, computational or not, behind the performance or simulation. Thirdly, “Tech. Support” in the simulation/performance group reports on the ground technological components being used by the system.

Another group of features describes the authorship facilities that the proposals offer. In the case that authorship tools are missing, the proposal would be more oriented to the consumption of contents although some sort of programming is still present. This is an important aspect under the perspective of Abt, since the special relevant task is more about playing to create the artifact rather than consuming the game. Of course, consumption of preestablished contents is useful as a means to convey knowledge and skills. Moreover, the existence of authorship tools can suit a wider range of activities as reclaimed by McFarlane et al. (2002) and Gros (2007) in their studies on predefined software.

The “World construction” feature simply indicates whether the system allows users the construction of a world ecosystem or not. This means that at least some preestablished components or entities can be arranged arbitrarily to make up a world. Similarly, the “Entity/Component construction” feature indicates whether an editing tool is provided to create the entities or components to populate the world ecosystem. The “Entity Creation Tech. Support” feature reports on the ground technological components being used by the system to support this. Finally, the “Behavior construction” and “Behavior Tech. Support” features are similar to the previous ones but focused on the behavior specification by users.

Tables 17.1 and 17.2 show how there are a range of different technologies being used to support the simulation of world ecosystems or the performance by users based on games but mainly with learning purposes. Clearly, there are two groups of proposals. Those that support the creation of the main elements or entities to be involved in the world ecosystem and those that do not. Most systems support some sort of behavior specification given by the end user in terms of instructions or programs. The programming tools are mostly based on drag&drop metaphors using

Table 17.1 Work comparison: programming and performing in a preestablished world

						Simulation/performance			Authorship				
	Work	Aim	Target users	Study	Social interact.	Ecosystem type	Behavior spec.	Techno-logical support	World construc-tion	Entity/com-ponent	Entity tech. support	Behavior con-struction	Behavior tech. Support
Creating behavior in pre-existing worlds	Algoblock	L	Children (12)	y	C	2D virtual	Procedure	Tangibles + PC	n	n	–	y	Tangible blocks
	Cleogo	L	Children	n	N	2D virtual turtle	Procedure	PC	n	n	–	y	Textual code/ drag&drop
	TurTan	L		n	C	2D virtual turtle	Procedure	Tabletop	n	n	–	y	Tangibles
	Tangible spaces	L	Children (6–12)	y	C	2D virtual/ tangible entities	Procedure	Projec-tion screen + tan-gible cards + carpet	y	n	–	y	Tangible cards
	Incretable	E	–	y	C	Tangible and virtual parts	Physics simula-tion	Mixed reality (table-top + robots)	n	n	–	y	Tangibles
	Quetzal/ Tern	L	1st/2nd-grade children	y	C	Virtual/ actual entity robots	Proce-dure + physics con-straints	Robots	y	n	–	y	Tangibles
	StoryTell-ing Alice	L	Novice pro-grammers/ girls	y	–	3D virtual	Procedure	PC	y	n	–	y	Drag&drop metaphor (PC)

Table 17.2 Work comparison: creation of characters for an interactive world

						Simulation/performance			Authorship				
	Work	Aim	Target users	Study	Social interaction	Ecosystem type	Behavior spec.	Technogical support	World construction	Entity/component construction	Entity tech. support	Behavior construction	Behavior tech. support
Creating Entities for Interactive Worlds	*Logoblocks*	L	Lego brick programmers	n	C	Tangible robots	Procedure (virtual blocks)	Robots	y	y	PC	y	Drag&drop (in PC)
	Scratch	L	Children and teenagers	y	–	2D virtual entities	Procedure (virtual blocks)	PC	y	y	PC	y	Drag&drop (in PC)
	Agentsheets	L	Any	n	–	2D virtual entities	Rules	PC	y	y	PC	y	Drag&drop in GUI
	Topobo	L	Children	y	–	3D tangibles entities	Procedure	Tangible robots	y	y	Tangible-manual	y	Kinetic robotic memory
	ShadowStory	L	Children	y	C	2D virtual	Performance orienteering sensors	PC-proj.+ screen	y	y	Tangible-manual	n	–
	AGORAS	L	Teenagers	y	C	2D virtual entities	Physics + rules	Tabletop	y	y	Tabletop	y	Tabletop: dataflows in rules

WIMP interaction to facilitate the construction of programs by nonprogrammers or children.

Tangible interaction is a growing paradigm, which offers tangible affordances and metaphors to facilitate interaction. It is the preferred choice in systems that only allow the specification of behavior in preestablished worlds. It proves that tangible languages have gained significant attention from the community and they are being used when the task at hand is primarily focused on programming behavior. However, the adoption of tangible interaction has been slow in the case of systems that also supported the creation of the world and entities. It shows how difficult integrating creative assembling functionality with behavior specification is. As a result, those systems missed offering social interaction and therefore limiting their opportunity for learning.

5 Conclusion

This chapter has discussed the role of digital games as tools in learning settings. The work review has shown that many systems have been developed supporting the creation of digital games with the aim of providing flexible settings for active learning. The degree of creation supported has been diverse. On the one hand, an important strand of work has been focused on entity behavior specification in preestablished worlds. They have mostly been based on tangible interfaces which facilitate social interactions in small groups as well as lower cognitive effort to use the systems. On the other hand, a significant effort has been made in offering tools for creating complete digital game worlds from scratch. Due to the greater functionality and inherent complexity, more traditional nontangible interfaces based on keyboard and mouse input peripherals have been used, although there are some recent systems capable of providing active game creation experiences by means of tangible technology.

Acknowledgments This work received financial support from the Spanish Ministry of Education under the National Strategic Program of Research and Project TIN2010–20488. Our thanks go to Polimedia/UPV for the support in computer hardware and the researchers who supplied some artwork. This work is also supported by a postdoctoral fellowship within the VALi + d program from Conselleria d'Educació, Cultura i Esport (Generalitat Valenciana), to A. Catala (APOSTD/2013/013).

References

Abt, C. (1970). *Serious games*. New York: Viking Press.

Aragon, C., Poon, S., Monroy-Hernandez, A., & Aragon, D. (2009). *A tale of two online communities: Fostering collaboration and creativity in scientists and children*. Proceedings of C & C 2009, pp. 9–18.

Begel, A. (May 1996). *LogoBlocks: A graphical programming language for interacting with the world*. Cambridge: Massachusetts Institute of Technology.

Catala, A., Jaen, J., Martinez-Villaronga, A., & Mocholi, J. A. (2011). AGORAS: Exploring creative learning on tangible user interfaces. Computer Software and Applications Conference (COMPSAC), 2011 IEEE 35th Annual, pp. 326–335.

Catala, A., Garcia-Sanjuan, F., Azorin, J., Jaen, J., & Mocholi, J. A. (2012a). Exploring direct communication and manipulation on interactive surfaces to foster novelty in a creative learning environment. *International Journal of Computer Science Research and Application, 2*(1), 15–24.

Catala, A., Garcia-Sanjuan, F., Pons, P., Jaen, J., & Mocholi, J. A. (2012b). *AGORAS: Towards collaborative game-based learning experiences on surfaces*. Proceedings of the International conference on cognition and exploratory learning (CELDA 2012), pp. 147–154, IADIS, Madrid, 19–21 Oct 2012. ISBN 978-989-8533-12-8.

Catala, A., Jaen, J., van Dijk, B., & Jordà, S. (2012c). *Exploring tabletops as an effective tool to foster creativity traits*. Proceedings of the sixth International conference on tangible, embedded and embodied interaction (pp. 143–150). New York: ACM. http://doi.acm.org/10.1145/2148131.2148163.

Cockburn, A., & Bryant, A. (1998). *Cleogo: Collaborative and multi-metaphor programming for kids*. Proceedings of the third Asian Pacific computer and human interaction (APCHI'98), pp. 189–194.

Fernaeus, Y., & Tholander, J. (2006). *Finding design qualities in a tangible programming space*. Proceedings of the SIGCHI Conference on Human Factors in Computing Systems CHI'06, pp. 447–456.

Fernaeus, Y., Tholander, J., & Jonsson, M. (2008). Beyond representations: towards an action centric perspective on tangible interaction. *International Journal of Arts and Technology*, *1*(3–4), 249–267.

Gallardo, D., Julia, C., & Jorda, S. (2008). TurTan: A tangible programming language for creative exploration. Horizontal Interactive Human Computer Systems, 2008. TABLETOP 2008. 3rd IEEE International Workshop on, pp. 89–92, doi:10.1109/TABLETOP.2008.4660189. http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber=4660189

Gros, B. (2007). *The design of learning environments using videogames in formal education*. Proceedings of the first IEEE International workshop on digital game and intelligent toy enhanced learning (pp. 19–24). Washington, DC: IEEE Computer Society. http://dx.doi.org/10.1109/DIGITEL.2007.48.

Horn, M. S., & Jacob, R. J. (2007). *Designing tangible programming languages for classroom use*. Proceedings of the 1st International conference on tangible and embedded interaction (pp. 159–162). New York,: ACM. http://doi.acm.org/10.1145/1226969.1227003.

Kelleher, C., & Pausch, R. (2005). Lowering the barriers to programming: A taxonomy of programming environments and languages for novice programmers. *ACM Computing Surveys, 37*(2), 83–137.

Kelleher, C., & Pausch, R. (July 2007). Using storytelling to motivate programming. *Magazine Communications of the ACM—Creating a Science of Games, 50*(7), 58–64.

Kelleher, C., Pausch, R., & Kiesler, S. (2007). *Storytelling alice motivates middle school girls to learn computer programming*. Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (pp. 1455–1464). New York: ACM. http://doi.acm.org/10.1145/1240624.1240844.

Leitner, J., Haller, M., Yun, K., Woo, W., Sugimoto, M., & Inami, M. (2008). *Incretable, a mixed reality tabletop game experience*. Proceedings of the Conference on Advances in Computer Entertainment Technology (ACE 2008), pp. 9–16.

Leitner, J., Haller, M., Yun, K., Woo, W., Sugimoto, M., Inami, M., & Cheok, A. D., Been-Lirn, H. (2009 Dec). Physical interfaces for tabletop games. *ACM Computers in Entertainment, 7*(4), Article 61.

Lu, F., Tian, F., Jiang, Y., Cao, X., Luo, W., Li, G., Zhang, X., Dai, G., Wang, H. (2011). *ShadowStory: creative and collaborative digital storytelling inspired by cultural heritage*. Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, (pp. 1919–1928). New York: ACM. http://doi.acm.org/10.1145/1978942.1979221.

Maloney, J., Burd, L., Kafai, Y., Rusk, N., Silverman, B., & Resnick, M. (2004). *Scratch: A sneak preview*. Proceedings of the second International Conference on Creating, Connecting and

Collaborating Through Computing, (pp. 104–109). Washington, DC: IEEE Computer Society. http://dx.doi.org/10.1109/C5.2004.33.

McFarlane, A., Sparrowhawk, A., & Heald, Y. (2002). Report on the educational use of games. TEEM/DfES.

Michael, D., & Chen, S. (2006). Serious games: games that educate, train, and inform. Thomson Course Technology. http://books.google.es/books?id=49kTAQAAIAAJ.

Papert, S. (1985). Different visions of logo. *Computers in the School, 2*(2–3), 3–8.

Parkes, A., Raffle, H., & Ishii, H. (2008). *Topobo in the wild: Longitudinal evaluations of educators appropriating a tangible interface*. Proceedings of the SIGCHI Conference on Human Factors in Computing Systems CHI'08, pp. 1129–1138.

Raffle, H., Parkes, A., & Ishii, H. (2004). *Topobo: A constructive assembly system with kinetic memory*. Proceedings of the SIGCHI conference on human factors in computing systems CHI'04, (pp. 647–654).

Repenning, A., Ioannidou, A., & Zola, J. (2000). AgentSheets: End-user programmable simulations. *Journal of Artificial Societies and Social Simulation, 3*(3), 351–358.

Resnick, M. (2002). Rethinking learning in the digital age. In G. Kirkman (Ed.), *The global information technology report: Readiness for the networked world*. Oxford: Oxford University Press. http://web.media.mit.edu/\~{}mres/papers/wef.pdf.

Suzuki, H., & Kato, H. (1995). Interaction-level support for collaborative learning: AlgoBlock\—an open programming language. The First International Conference on Computer Support for Collaborative Learning, (pp. 349–355). Hillsdale: Erlbaum. http://dx.doi.org/10.3115/222020.222828.

Chapter 18
Augmented Reality and Learning in Science Museums

Susan A. Yoon, Joyce Wang and Karen Elinich

1 Introduction

Increasingly, informal science environments have been highlighted for their potential to improve science understanding and participation in daily science activities and scientific careers (Banks et al. 2007; NRC 2009, 2011). There are many good reasons for this, which include engagement, fun, and self-directed learning (Falk and Dierking 1992, 2000; Little et al. 2008)—qualities that often stand in contrast to traditional formal school experiences (NRC 2009). However, these unique informal learning characteristics also, in part, pose challenges in developing a deeper understanding of science content and practices (McManus 1994) due to learning that occurs in typically short, sporadic visits (NRC 2009; Silverstein et al. 2008).

One of the primary purposes of designed informal environments such as science museums is to help visitors engage with scientific phenomena. Research in this domain has demonstrated that visitors can gain understanding of scientific concepts, arguments, explanations, models, and facts even after just one visit to the museum (NRC 2009). For example, conversations between children and their parents during museum visits reveal that families sometimes integrate scientific resources gained from their engagement with the exhibit with nonscientific knowledge, to make sense of the exhibit content (Zimmerman et al. 2010). Despite the enormous value of this and other similar research (e.g., Palmquist and Crowley 2007; Tare et al. 2011), these studies are largely qualitative in nature and present self-reported and conversational data. Few have focused on knowledge improvement that captures the added value of an exhibit in comparison to what visitors already know, and even fewer have analyzed learning through experimental designs. Furthermore, the extent to which visitors are learning scientific concepts and the supports needed to

S. A. Yoon (✉) · J. Wang
University of Pennsylvania Graduate School of Education, 3700 Walnut Street, 19104
Philadelphia, PA, USA
e-mail: yoonsa@gse.upenn.edu

K. Elinich
The Franklin Institute, 222 North 20th Street, 19103 Philadelphia, PA, USA

D. G. Sampson et al. (eds.), *Digital Systems for Open Access to Formal and Informal Learning,* DOI 10.1007/978-3-319-02264-2_18,

do this are not well understood, as the NRC (2009) report suggests that overall assessment of scientific knowledge shows little positive change. In light of this, there has been growing emphasis on increasing the impact of these environments through designing additional learning scaffolds such as postvisit web activities and follow-up e-mail contact (NRC 2009). Technological tools for enhancing learning and engagement in informal settings have also gained momentum (e.g., Falk and Dierking 2008; Hall and Bannon 2006) and can potentially serve the purpose of scaffolding extended experiences to improve short-term learning.

Collectively, the NRC report (2009) outlines the need for essential research in three key areas. First, while there is ample evidence that suggests informal environments increase engagement and interest, fewer studies have focused on how those experiences result in conceptual gains of science content. Second, in terms of scientific skills, designed interactives have been shown to increase lower-level skills such as manipulating and observing; however, more challenging skills such as critical thinking and theorizing are less frequently demonstrated. Finally, as digital platforms are increasingly incorporated in informal settings, more research is needed to determine how they enhance the learning experience.

In this chapter, we present our findings from our project ARIEL—*Augmented Reality for Interpretive and Experiential Learning*—which investigates these three areas of concern. Over the last 3 years, we have piloted and investigated the impact of a field-tested, exportable, and replicable system for the overlay of augmented reality (AR) interfaces onto fixed-position science museum exhibit devices. The goal was the creation of an open-source exhibit platform that uses digital scientific visualization to transform visitor interaction with traditional hands-on exhibits by merging the experiential and interpretive aspects of the encounter. While the project is ongoing, it has generated research findings of interest to the informal science education and exhibit development communities.

2 Features of Museum Learning

Science museums are a specific type of informal learning environment in which the setting is intentionally designed to facilitate free-choice learning (Allen 2004; NRC 2009). Whereas learning in formal classrooms relies on teachers to construct the learning experience for students, learning in museums is entirely dependent on the visitors' curiosity, intrinsic motivation, choice, and control (Falk 2004; Pedretti 2002; Rennie and McClafferty 1996). What is learned and how it is learned is at the volition of the visitor. As a result, learning in these spaces is fluid, sporadic, social, and participant driven—characteristics that contrast the highly structured formal classroom experience (Honey and Hilton 2011; NRC 2009; Squire and Patterson 2009). Activities are often experienced in single-visit episodes (Falk et al. 2007), and learning typically relies on the design of the spaces and the experiences and responses they elicit in visitors. McManus (1994) has characterized typical visitors as demonstrating scouting behaviors within museum exhibits, where they roam around, encounter devices, and act quickly to discover the intended information. Thus, more systematic learning studies are difficult to design. However, science museum exhibit developers do intentionally design learning spaces that mix a variety of supports for learning.

2.1 Interactive Exhibits

One way science museums engage with visitors, to motivate them to stay and invest their time, energy, and attention, is by offering interactive experiences. Ultimately, the ability of an exhibit or a device to "interact" with an individual depends on an exchange of action and reaction between the two, where a visitor acts on an exhibit and the exhibit responds in some way (Allen and Gutwill 2004). These interactive exhibits allow visitors to conduct explorations, gather evidence, select from a variety of choices, form conclusions, test skills and hypotheses, provide input, and sometimes alter an outcome based on their input (McLean 1993).

Because interactive exhibits allow visitors to participate in these ways, they have been found to attract more visitors and to engage them for a longer period of time as compared to static exhibits (e.g., Allen 2007; Borun 2003). In addition to enticing visitors to stay, interactive museum exhibits also claim to increase visitor learning and recall of exhibits and their content (Allen and Gutwill 2004). Essentially, when visitors interact with these devices, their manipulation causes them to gain "understanding of science and technology by controlling and watching the behavior of laboratory apparatus and machinery" (Oppenheimer 1968). Indeed, visitors have self-reported learning knowledge and skills, gaining new perspectives, and generating enthusiasm and interest through interaction with these exhibits (Falk et al. 2004).

As designing for effective interactive experiences in science museums continues to be a highly researched area (e.g., Allen 2004; Allen and Gutwill 2004), media and technology are increasingly being explored as tools that can communicate science and foster learning, engagement, and interactive experiences (Heath and vom Lehn 2008). While usability studies have revealed high levels of engagement and enjoyment from participants who engage with these tools, there needs to be more research that demonstrates how interaction with these tools mediates conceptual learning (NRC 2009). "Ultimately, the goal of introducing new media technologies into designed science learning environments is not only to modernize the experience and space, but to significantly improve the quality of the visitor experience, including enhancing learning outcomes" (NRC 2009, p. 270).

2.2 Exhibit Labels

Additionally, museums also integrate posted graphic panels, or labels, (Serrell and Adams 1998, 2006) that provide printed content to support the interpretation of scientific phenomena. Typically exploratory in nature, labels have been found to impact visitors' experiences in various ways, including increasing the likelihood of their understanding and their ability to find meaning in and enjoy museum exhibitions when labels are written clearly to express the goals of the exhibit. Some studies have documented how different types of labels change the way visitors interact with exhibits (e.g., Atkins et al. 2008), while other studies have investigated how labels affect the type of conversations that ensue between group members (e.g., Hohenstein and Tran 2007). Ultimately, labels seek to increase visitors' learning and to contribute to greater cognitive gains (Borun and Miller 1980; Falk 1997; NRC 2009) by framing perceptions, offering contrasting perspectives, challenging assumptions, and providing explanations (Gutwill 2006). Labels, which offer essential information to the understanding of exhibit devices (Wolf and Smith 1993), are employed such that the visitor learns to see "museum things…in the varied cognitive frameworks of scientific knowledge" (Borun and Miller 1980). In a study performed at the Franklin Institute, Borun and Miller determined that the average visitor reads exhibit labels and that these labels potentially improve their understanding and experience. Similarly, Falk (1997) found that visitors demonstrated significant conceptual development when the exhibit was explicitly labeled with a summary of the main message. Ultimately, well-written labels have the potential to successfully increase visitor understanding.

3 Knowledge-Building Scaffolds

The use of labels in museum spaces serves as instructional scaffolds that are meant to promote deeper learning. By directing visitors' attention toward relevant and essential aspects of scientific phenomena, labels enhance visitors' comprehension of the exhibit.

The use of scaffolds in educational technology applications has been researched fairly extensively to support scientific inquiry and cognitive tasks (e.g., Quintana et al. 2004). In particular, a long-standing program of research in the learning sciences that is premised on designing learning environments through the intentional application of technological and pedagogical scaffolds is *knowledge building* (Bereiter 2002; Scardamalia 2002; Scardamalia and Bereiter 2006; Yoon 2008, 2011). This approach is centrally focused on the goal of improving ideas in the same way that knowledge work is done by experts in real-world contexts (Scardamalia and Bereiter 2006). Primarily applied in school classrooms, knowledge-building studies have been shown to increase students' scientific abilities in explanation, interpreting and evaluating information, and knowledge advancement (van Aalst 2009). Students also acquire deep theoretical understanding of scientific phenomenon through collective sustained inquiry and research on problems that can range from what causes leaves to change color in the fall in a grade 1 classroom (Scardamalia 2002) to the complex influences of genetic engineering research with middle and high school students (Yoon 2008, 2011).

The technological application, knowledge forum, and associated pedagogy use educational scaffolds to enable public, collective contributions that shape the knowledge constructed in the learning community. Such scaffolds include *prompts* for consensus building, generalizations, differentiation between evidence and theories, and peer evaluation. For example, a prompt such as "*My theory is…*" encourages students to use evidence to construct a more general understanding of a class of scientific phenomena. Similarly, students can create a "rise above" note, enabled by the *archived database* of peer exchanges, which is a distillation of an idea or theory from a collection of previous peer exchanges that provide students with opportunities to think across diverse perspectives and to arrive at conclusions about how the collective learning community views a scientific issue (Yoon 2008).

Collaboration also factors prominently into the knowledge-building approach. By working with others discursively to problem solve, evaluate evidence, and identify important *shared understanding,* students are able to more deeply reflect on what they know rather than learning independently or learning through textual modes. This decentralized, public, and distributed participation promotes what Scardamalia (2002) calls *collective cognitive responsibility,* where the impetus for learning is *generated by consensus* within the community rather than by the teacher. From this set of theoretical and pedagogical descriptions, our series of studies uses varying degrees of what we collectively refer to as knowledge-building scaffolds, which include knowledge prompts, a bank of peer ideas, working in collaborative groups, instructions for generating consensus, and worksheets for recording shared understanding. However, because knowledge building requires the development of a community with shared understanding, language, and goals, learning events evolve over longer periods of time than informal environments may afford. Van Aalst (2009) characterizes learning experiences that are less focused on the community as knowledge construction in which students may collaborate in small groups on tasks that require less synthesis and reflection on the knowledge-advancement process. We have understood the limitation of our informal setting and population in terms of achieving a true knowledge-building community in previous studies (e.g., Yoon et al. 2012b) but have, nevertheless, attempted to investigate how aspects of knowledge-building pedagogy can be applied in informal environments, given its success in formal classrooms.

4 Augmented Reality

In the most recent *Horizon Report,* the New Media Consortium (2012) discusses the enormous potential AR capabilities have on learning and assessment in enabling people to construct new understanding. AR experiences layer digital displays over three-dimensional (3D) real-world environments (New Media Consortium 2012) to provide access to normally hidden data, thereby allowing users to experience and perceive the newly incorporated information as part of their present world. In this way, AR serves as a scaffold by supporting the user with additional (virtual) information, which might not be directly detected by their senses, to aid in their performance of specific tasks. It is precisely in this scaffolding role that AR offers the unique potential to transform learning at multiple levels.

In the past decade, practical uses of AR have emerged in fields such as games, marketing and advertising, films, navigation, and for medical and military applications (El Sayad et al. 2011). Although newer in education, over the last few years, there have been studies that illustrate AR's potential for learning, particularly in the field of science education. For example, Dunleavy et al. (2009) document high student engagement and motivation influenced by the ability to collaboratively problem solve and collect data in the real world in their handheld AR environment called *Alien Contact!* Squire and Klopfer (2007) detail the impact of their AR game *Environmental Detectives* on accessing students' prior knowledge by connecting academic content to physical spaces that students are familiar with. In *Outbreak @ The Institute,* Rosenbaum et al. (2007) document the affordance of their AR game play to include authentic scientific inquiry and understand the dynamic nature of system interactions. In these studies, the indirect correlates of student learning, i.e., engagement, prior knowledge, and processes in scientific practice, are important outcomes of the research and provide valuable impetus for pursuing further studies on what and how students learn in terms of scientific knowledge.

AR technology is also starting to slowly extend into museum spaces. However, as most of these technologies are prototypes and still in the development stages, research studying their use in museums is largely concerned with the design, evaluation, and usability of these applications (NRC 2009). For example, some studies have investigated the development of guidebooks to support visitors' navigation and interactions throughout the museum (e.g., Damala et al. 2008; Szymanski et al. 2008), while others have studied the technological design, architecture, and implementation of an AR system (e.g., Koleva et al. 2009; Vlahakis et al. 2001; Wojciechowski et al. 2004). While these studies do not specifically examine the impacts on visitor learning, they do offer important insight regarding the general effects AR has on visitor behavior. For instance, Szymanski et al. (2008) revealed that the augmented guidebooks, which provided information about the artifacts that visitors encountered, increased visitors' exploration of the objects and led to more content-rich discussions between them. Hall and Bannon (2006) demonstrated that children's engagement and interest increased when they interacted with several museum artifacts that were augmented. Damala et al. (2008) also tested an AR-enabled mobile multimedia museum guide in a fine arts museum and found that visitors enjoyed the playful content presentation that the museum guide enabled. Asai et al. (2010) reported that an AR lunar surface navigation system implemented at a science museum exhibit encouraged more collaborative interactions between parents and their children. Collectively, these studies demonstrate that AR as a visualization tool has the potential to support learning behaviors. From conveying spatial information about scientific elements essential to understanding and visualizing phenomena to increasing collaboration and engagement between its users,

Fig. 18.1 Be the Path

AR technology offers promise for transforming learning, and specifically, science museum learning.

5 ARIEL Project

5.1 Overview of ARIEL Devices

To date, three devices have been digitally augmented and their impact on schoolchildren visitors have been investigated. The first augmented device is called "Be the Path," represented in Fig. 18.1. This device invites students to learn about electrical circuits, current electricity, and conductivity. When the students complete the circuit with their bodies, the digital augmentation is triggered, showing a digital animation of the flow of electrons through them. If the circuit breaks, the animation disappears. The digital augmentation draws students into creative, collaborative exploration of the topic. The posted label copy includes questions to spark conversation and guide collaboration.

The second augmented device, "Magnetic Maps," is shown in Fig. 18.2. This device invites students to manipulate two bar magnets and feel the attractive and repulsive forces between them. On screen, the AR responds dynamically to the position of the magnets in real time, drawing a visualization of the magnetic force field that surrounds the two bar magnets. As the students move the magnets, the visualization changes on screen, encouraging them to engage more deeply and for a longer time.

Finally, the latest augmented device, "Bernoulli Blower," is depicted in Fig. 18.3 below. This device invites students to "make the red ball float" in the stream of fast-moving air and to learn about fluid dynamics. On screen, a real-time visualization of the variable air pressures illustrates where the ball is trapped between the forces. The on-screen label copy invites deeper engagement and group conversation.

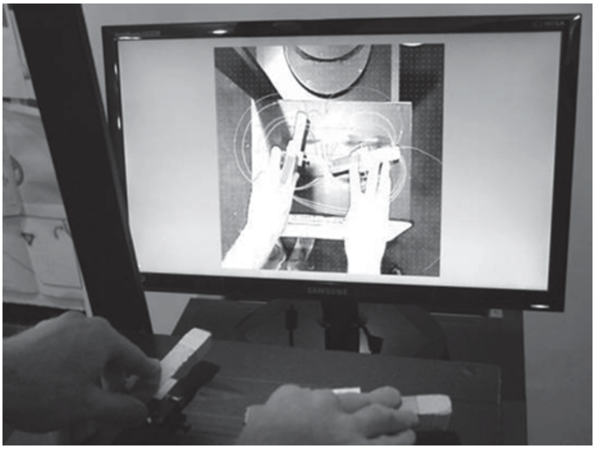


Fig. 18.2 Magnetic Maps

Fig. 18.3 Bernoulli Blower

5.2 Overview of Studies and Findings

Our research team has conducted a series of studies that investigates how digitally augmented devices and knowledge-building scaffolds (Scardamalia 2002; Scardamalia and Bereiter 2006) enhance science learning in a science museum (Wang and Yoon 2013; Yoon et al. 2011, 2012a, b, 2013). In the series, we use a quasi-experimental design in which students in multiple conditions interact with a museum device using digitally augmented information and varying arrangements of knowledge scaffolds. In total, we have worked with 710 middle school students (grades 5–8) from a wide range of public and charter schools. Figure 18.4 provides a diagrammatic example of one study in which data were collected from four different conditions using the ARIEL device called “Be the Path.”

The first condition represents the exhibit device as it is presently on the museum floor, without any additional labels and scaffolds. In the second condition, the application of a digital augmentation to an exhibit device provides a first layer of interpretive support and acts as a primary scaffold. We then added posters and worksheets with progressively more rigid layers of structure around the experience to advance the scaffolding for analysis. For example, in the third condition, we

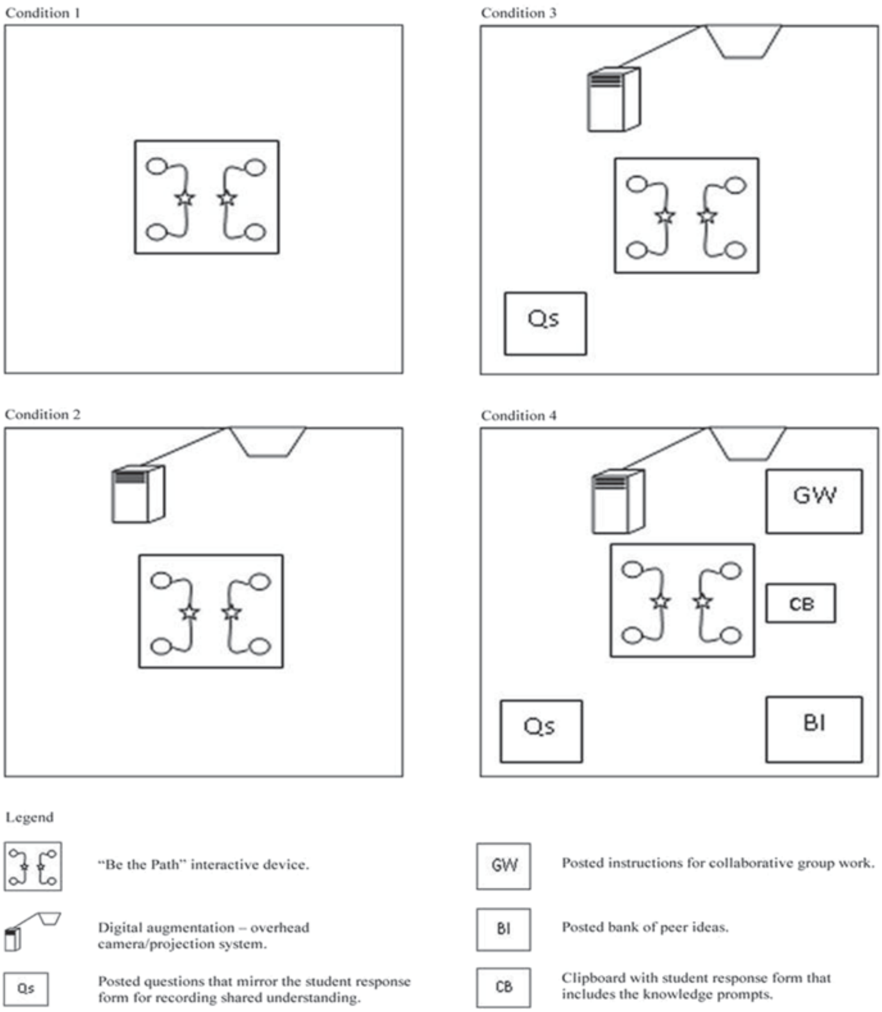


Fig. 18.4 Condition configurations of one study of the *Be the Path* device

included question labels that directed visitors to perform certain activities and that prompted them to consider what the augmentation was showing. In the fourth condition, we required group work as a strategy for measuring the benefits of collaboration. We also provided several knowledge-building scaffolds including a bank of ideas and sentence starters to measure the frequency of theory building. (For a more thorough description of the different conditions, please refer to Yoon et al. 2012a.)

Several major findings have resulted from our studies of these three devices. First, analysis of conceptual pre-/postsurveys reveals that digital augmentation can improve visitors' understanding of the science concepts that underlie the phenomena being exhibited (Yoon et al. 2011, 2012a, b, 2013). We suggest that this is due to the affordances of AR as a digital visualization tool to make hidden, invisible information visible, to reveal dynamic processes and interactions, and to interact with the user (Yoon and Wang 2014). Second, students' abilities to interpret information about a phenomenon using knowledge-building scaffolds can improve cognitive understanding (reasoning skills) in some conditions (Yoon et al. 2011, 2012a); however, this may come at the expense of the characteristics of informal exploration that make informal learning environments so engaging (Yoon et al. 2013). Finally, group work and collaboration have been identified as the most beneficial scaffold for helping schoolchildren visitors learn (Yoon et al. 2011, 2012b, 2013).

6 Conclusion

One outcome of the project has been the emergence of an evidence-based ARIEL learning model, which we believe has core relevance for research in augmented informal learning environments. The ARIEL learning model includes four parts:

1. Exhibit devices with digital augmentations that respond to visitor action (AR)
2. Scaffolds for learning (scaffolds)
3. Social interaction through peer collaboration at device (collaboration)
4. Informal characteristics, e.g., free choice, playful, hands on (informal participation)

While previous research on the use of AR in museum environments has revealed little about their impacts on learning outcomes (NRC 2009), we have found that AR technology has the potential to significantly enhance learning of science concepts in museums. Particularly because science is often concerned with products that are too small or processes that are too complex or abstract, AR affords individuals the capacity to visualize and interact with these invisible aspects, thereby enhancing their ability to then make sense of the information. Additionally, because of the nature of informal learning, that it is fluid, sporadic, and largely facilitated by the visitors themselves, incorporating scaffolds for learning and collaboration are essential to designing an environment that supports and guides participation and engagement toward deeper learning.

Through this model, we have seen important learning gains but they have been modest in some cases, in part due to the unique challenges of participation in informal learning environments. Our studies have investigated the tension between informal and more formalized learning approaches, and we have pushed against the boundaries of what typical learning scaffolds might look like in a museum, for the purpose of enhancing science learning. We offer this model as a framework for designing exhibit experiences that are not only fun and engaging but can also support deeper learning.

Acknowledgments An earlier version of this research was presented at the CELDA (2012) conference (Yoon and Elinich 2012). This research was funded by the National Science Foundation DRL Grant #0741659. Conclusions or recommendations expressed in this material are our own and do not necessarily reflect the view of the National Science Foundation.

References

Allen, S. (2004). Designs for learning: Studying science museum exhibits that do more than entertain. *Science Education, 88*(Suppl 1), S17–33. doi:10.1002/sce.20016.

Allen, S. (2007). Secrets of circles summative evaluation report. Report prepared for the Chidlrne's disocvery museum of Sna Jose. http://informalscience.org/evaluations/report_252.PDF. Accessed 1 April 2010.

Allen, S., & Gutwill, J. (2004). Designing with multiple interactives: Five common pitfalls. *Curator, 47*(2), 199–212.

Asai, K., Sugimoto, Y., & Billinghurst, M. (2010). *Exhibition of lunar surface navigation system facilitating collaboration between children and parents in science museum*. In Proceedings of the 9th ACM SIGGRAPH Conference on Virtual Reality Continuum and its Application in Industry, pp. 119–124.

Atkins, L., Velez, L., Goudy, D., Dunbar, K. (2008). The unintended effects of interactive objects and labels in the science museum. *Science Education, 93,* 161–184. doi:10.1002/sce.20291.

Banks, J., Au, K., Ball, A., Bell, P., et al. (2007). *Learning and out of school in diverse environments: Life-long, life-wide, life-deep*. Washington, DC: The LIFE Center.

Bereiter, C. (2002). *Education and mind in the knowledge age*. Mahwah: Lawrence Erlbaum.

Borun, M. (2003). *Space command summative evaluation*. Philadelphia: Franklin Institute Science Museum. (http://informalscience.org/evaluations/report_24.pdf. Accessed 1 Sept 2011).

Borun, M., & Miller, M. (1980). What's in a name? A study of the effectiveness of explanatory labels in a science museum. Report prepared for The Franklin Institute Science Museum. http://eric.ed.gov/ERICWebPortal/search/recordDetails.jsp?accno=ED267966&ERICExtSearch_SearchValue_0=%2522Borun+Minda%2522&_pageLabel=RecordDetails&ERICExtSearch_SearchType_0=au. Accessed 1 April 2010.

Damala, A., et al. (2008). *Bridging the gap between the digital and the physical: Design and evaluation of a mobile augmented reality guide for the museum visit*. In 3rd ACM International Conference on Digital and Interactive Media in Entertainment and Arts (pp. 120–128). New York: ACM.

Dunleavy, M., et al. (2009). Affordances and limitations of immersive participatory augmented reality simulations for teaching and learning. *Journal of Science Education and Technology, 18,* 7–22.

El Sayad, N., et al. (2011). ARSC: Augmented reality student card. An augmented reality solution for the education field. *Computers & Education, 56,* 1045–1061.

Falk, J. H. (1997). Testing a museum exhibition design assumption: Effect of explicit labeling of exhibit clusters on visitor concept development. *Science Education, 81,* 679–687.

Falk, J. (2004). The director's cut: Toward an improved understanding of learning from museums. *Science Education, 88*(Suppl 1), S83–96.

Falk, J., & Dierking, L. (1992). *The museum experience*. Washington, DC: Whalesback Books.

Falk, J. H., & Dierking, L. D. (2000). *Learning from museums: Visitor experiences and the making of meaning*. Walnut Creek: AltaMira.

Falk, J., & Dierking, L. (2008). Enhancing visitor interaction and learning with mobile technologies. In L. Tallon & K. Walker (Eds.), *Digital technologies and the museum experience: Handheld guides and other media,* (pp. 19–33). Plymouth: AltaMira.

Falk, J., Scott, C., Dierking, L., Rennie, L., & Jones, M. (2004). Interactives and visitor learning. *Curator, 47*(2), 171–192.

Falk, J. H., Dierking, L. D., & Foutz, S. (Eds.). (2007). *Principle-in practice: Museums as learning institutions*. Lanham: AltaMira.

Gutwill, J. (2006). Labels for open-ended exhibits: Using questions and suggestions to motivate physical activity. *Visitor Studies Today, 9*(1), 1–9.

Hall, T., & Bannon, L. (2006). Designing ubiquitous computing to enhance children's learning in museums. *Journal of Computer Assisted Learning, 22*(4), 231–243.

Heath, C., & vom Lehn, D. (2008). Enhancing engagement in science centres and museums. *Social Studies of Science, 38*(1), 63–91.

Hohenstein, J., & Tran, L. (2007). Use of questions in exhibit labels to generate explanatory conversation among science museum visitors. *International Journal of Science Education, 29*, 1557–1580.
Honey, M. A., & Hilton, M. (Eds.). (2011). *Learning science through computer games and simulations*. Washington, DC: National Academies.
Koleva, B., Egglestone, S., Schnadelbach, H., Glover, K., Greenhalgh, C., Rodden, T., & Dade-Robertson, M. (2009). *Supporting the creation of hybrid museum experiences*. In the Proceedings of the 27th International Conference on Human Factors in Computing Systems 2009 (pp. 1973–1982). New York: ACM.
Little, P. M., Wimer, C., & Weiss, H. B. (2008). *After school programs in the 21st century: Their potential and what it takes to achieve it*. Cambridge: Harvard Family Research Project.
McLean, K. (1993). *Planning for people in museum exhibitions*. Washington, DC: American Association of Museums.
McManus, P. (1994). Families in museums. In L. Miks & A. Zavala (Eds.), *Towards the museum of the future* (pp. 81–118). London: Routledge.
National Research Council. (2009). *Learning science in informal environments: People, places, and pursuits*. Washington, DC: National Academies.
National Research Council. (2011). *Successful K–12 STEM education: Identifying effective approaches in science, technology, engineering, and mathematics*. Washington, DC: National Academies.
New Media Consortium. (2012). *NMC horizon report: 2012 K-12 edition*. Austin: The New Media Consortium.
Oppenheimer, F. (1968). A rationale for a science museum. *Curator, 11,* 206–209.
Palmquist, S., & Crowley, K. (2007). From teachers to testers: How parents talk to novice and expert children in a natural history museum. *Science Education, 91,* 783–804.
Pedretti, E. (2002). T. Kuhn meets T. Rex: Critical conversations and new directions in science centers and science museums. *Studies in Science Education, 37,* 1–42.
Quintana, C., et al. (2004). A scaffolding design framework for software to support science inquiry. *Journal of Learning Sciences, 13*(3), 337–386.
Rennie, L., & McClafferty, T. (1996). Science centres and science learning. *Studies in Science Education, 27,* 53–98.
Rosenbaum, E., Klopfer, E., & Perry, J. (2007). On location learning: Authentic applied science with networked augmented realities. *Journal of Science Education and Technology, 16*(1), 31–45.
Scardamalia, M. (2002). Collective cognitive responsibility for the advancement of knowledge. In B. Smith (Ed.), *Liberal education in a knowledge society* (pp. 67–98). Chicago: Open Court.
Scardamalia, M., & Bereiter, C. (2006). Knowledge building. In K. Sawyer (Ed.), *The Cambridge handbook of the learning sciences* (pp. 97–115). New York: Cambridge University Press.
Serrell, B. (2006) *Judging exhibitions: A framework for assessing excellence*. Walnut Creek: Left Coast.
Serrell, B., & Adams, R. (1998). *Paying attention: Visitors and museum exhibitions*. Washington, DC: American Association of Museums.
Silverstein, G., Raue, K., Nyre, G., MacAllum, K., & Miyaoka, A. (2008). *Involving informal science institutions in K-12 STEM reform: Case study findings. WESTAT*. Maryland: Rockville.
Squire, K., & Klopfer, E. (2007). Augmented reality simulations on handheld computers. *Journal of the Learning Sciences, 16*(3), 371–413.
Squire, K., & Patterson, N. (2009). *Games and simulations in informal science education*. Paper commissioned for the National Research Council Workshop on Gaming and Simulations, October 6–7, Washington, DC. http://www7.nationalacademies.org/bose/Gaming_Sims_Commissioned_Papers.html. Accessed 1 April 2010.
Szymanski, M., et al. (2008). Sotto Voce: Facilitating social learning in a historic house. *Computer Supported Cooperative Work, 17*(1), 5–34.
Tare, M., French, J., Frazier, B., Diamond, J., & Evans, E. (2011). Explanatory parent-child conversation predominates sat an evolution exhibit. *Science Education, 95,* 720–744.

U.S. Department of Education. (2007). *Report of the academic competitiveness council*. Washington, DC: U.S. Department of Education.

van Aalst, J. (2009). Distinguishing knowledge-sharing, knowledge-construction, and knowledge-creation discourses. *International Journal of Computer Supported Collaborative Learning, 4*(3), 259–287.

Vlahakis, V., Karigiannis, J., Tsotros, M., Gounaris, M., Almeida, L., Stricker, D., Gleue, T., Christou, I., Carlucci, R., & Ioannidis, N. (2001). *ARCHEOGUIDE: First results of an augmented reality, mobile computing system in cultural heritage sites*. In Proceedings of the Conference on Virtual Reality, Archeology, and Cultural Heritage (VAST'01) (pp. 131–140). Glyfada, Greece.

Wang, J., & Yoon, S. (2013). Scaffolding visitors' learning through labels. *Journal of Museum Education, 38*(3), 320–332.

Wojciechowski, R., Walczak, K., White, M., & Cellary, W. (2004). *Building virtual and augmented reality museum exhibitions*. In Proceedings of the 9th International Conference on 3D Web Technology (pp. 135–144). New York, NY.

Wolf, L., & Smith, J. (1993). What makes museum labels legible? *Curator: The Museum Journal, 36*(2), 95–110. doi:10.1111/j.2151–6952.1993.tb00783.x.

Yoon, S. (2008). An evolutionary approach to harnessing complex systems thinking in the science and technology classroom. *International Journal of Science Education, 30*(1), 1–32.

Yoon, S. A. (2011). Using social network graphs as visualization tools to influence peer selection decision-making strategies to access information about complex socioscientific issues. *Journal of the Learning Sciences, 20*(4), 549–588.

Yoon, S., & Elinich, K. (2012). *Augmented reality in the science museum: Lessons learned in scaffolding for conceptual and cognitive learning*. In proceedings of the IADIS International Conference on Cognition and Exploratory Learning in Digital Age CELDA 2012. Madrid, Spain.

Yoon, S., & Wang, J. (2014). Making the invisible visible in science museums through augmented reality devices. *Tech Trends, 58*(1), 49–55.

Yoon, S., Elinich, K., Wang, J., Steinmeier, C., & Van Schooneveld, J. (2011). *Fostering critical thinking in science museums through digital augmentations*. In Proceedings of the annual conference of the International Conference on Computer Supported Collaborative Learning, Hong Kong, China.

Yoon, S., Elinich, K., Wang, J., Steinmeier, C., & Tucker, S. (2012a). Using augmented reality and knowledge-building scaffolds to improve learning in a science museum. *International Journal of Computer-Supported Collaborative Learning, 7*(4), 519–541. doi:10.1007/s11412–012-9156-x.

Yoon, S., Elinich, K., Wang, J., Steinmeier, C., & Van Schooneveld, J. (2012b). Learning impacts of a digital augmentation in a science museum. *Visitor Studies, 15*(2), 157–170. doi:10.1080/10645578.2012.715007.

Yoon, S., Elinich, K., Wang, J., Van Schooneveld, J., Anderson, E. (2013). Scaffolding informal learning in science museums: How much is too much? *Science Education, 97*(6), 848–877.

Zimmerman, H., Reeve, S., & Bell, P. (2010). Family sense-making practices in science center conversations. *Science Education, 94,* 478–505.

Chapter 19
From Teachers' to Schools' ICT Competence Profiles

Stylianos E. Sergis and Demetrios G. Sampson

1 Introduction

Information and communication technologies (ICT) have been repeatedly celebrated as a harbinger of teaching and learning enhancement. The diverse range of tools and services currently available has been reported to be beneficial in many aspects of teaching and learning processes (European Commission 2013). In order to reap these benefits and provide a driver for change, however, ICT needs to be incorporated into the fabric of schools, and not just be used as a tool for ad-hoc solutions (Micheuz 2009). Evidence shows that this is not the case, since schools have shown limited exploitation of the full range of ICT potential as an enabler of improved learning and teaching practices (European Commission 2010). This occurs despite the substantial advance in terms of technological infrastructure (Durando et al. 2007) and the significant number of initiatives (Eurydice 2011), policy adjustments (European Commission/EACEA/Eurydice 2012) and new paradigms for professional learning that attempt to battle this inconsistency (Duncan-Howell 2010).

The reasons for this inconsistency are multifaceted and multilevel, bearing in mind that schools are, themselves, complex entities with a vast range of interrelating factors (Solar et al. 2013). First of all, teachers, being core actors in the school

S. E. Sergis (✉)
Department of Digital Systems, University of Piraeus,
150 Androutsou Odyssea Street, GR-18532 Piraeus, Greece

Information Technologies Institute, Centre for Research
and Technology—Hellas, Thessaloniki, Greece
e-mail: steliossergis@iti.gr

D. G. Sampson
Department of Digital Systems, University of Piraeus,
150 Androutsou Odyssea Street, 18532 Piraeus, Greece
email: sampson@unipi.gr

Information Technologies Institute, Centre for Research
and Technology—Hellas, Thessaloniki, Greece
e-mail: sampson@iti.gr

D. G. Sampson et al. (eds.), *Digital Systems for Open Access to Formal and Informal Learning*,
DOI 10.1007/978-3-319-02264-2_19,

ecosystem, are usually regarded to have a significant part in the ICT integration process of their institutions. More specifically, research has shown that, among other reasons, their ICT competences (Sang et al. 2010) and personal attitudes towards ICT use (Tondeur et al. 2010) can greatly affect their level of ICT exploitation, and, therefore, influence their schools' ICT strategy.

However, teachers are not the only school component element whose actions can affect the institutional integration of ICT. Another significant factor are the school administrators/managers/principals etc. More specifically, their attitudes towards ICT (Tondeur et al. 2010), their ICT strategy planning decisions and the overall culture they cultivate within the school (Law and Chow 2008) can have an important impact at the level of ICT use.

Finally, apart from the human factors, other factors can also hinder ICT uptake in schools, such as ICT access and availability (Pelgrum 2008) or purely financial matters (Nachmias et al. 2004; Laurillard 2007).

Taking all the above into account, therefore, the complexity of the issue becomes more evident. The matter of identifying the reasons for the flailing school uptake of ICT and, more importantly, the paths to remedying for that, is neither straightforward nor trivial. Considering that schools are ecosystems with a wide range of interrelating component elements, the actions of which can affect the whole structure in unique ways (Zhao and Frank 2003), a holistic standpoint should be taken that effectively encapsulates all of the potential factors and their level of contribution.

Towards addressing this issue, this chapter first presents an overview of the concept of individual and organizational competence, in order to define the essential elements that affect it. Then, a discussion is performed on the concept of eMaturity (Durando et al. 2007), which is the current approach towards measuring ICT integration in educational institutions. This critical discussion is performed in order to (1) identify whether this approach and the frameworks that implement it accommodate the full spectrum of the important elements affecting ICT uptake in schools, as defined by the organizational competence analysis, and (2) propose improvements that would remedy for any identified gap.

More specifically, the full process involved a literature review to define the foundational elements of organizational competence, so as to use them as a benchmark for evaluating the current eMaturity approaches. Then, the existing eMaturity frameworks were content analysed in order to define which areas of school function they accommodate. Finally, a review was performed, by benchmarking the results of the latter analysis against the elements of organizational competence and identifying essential elements that are not currently being addressed.

This chapter, therefore, aims to highlight potential gaps in the existing school ICT integration measurement methods and to take a step towards amending these shortcomings by introducing new elements to be considered. By doing that, the proposed framework could allow for more holistic representations of the interrelating factors, as well as for the capturing of the *level of each factor's contribution* to the whole schema. A benefit from such an addition would be to not only detect impediments in the ICT uptake process, but also assist in the delineation of focused corrective paths.

The rest of the chapter is structured as follows. Section 2 provides the essential background on the concepts of individual and organizational competence, which will assist in identifying the core factors that affect school ICT integration processes. Section 3 presents an overview of the concept of eMaturity and the existing models for its measurement. Moreover, a critical discussion is performed in order to determine the sufficiency of the existing models to accommodate the full spectrum of school organizational competences. Section 4 presents a proposal towards a profiling framework for school ICT competences, which builds on eMaturity but extends to include additional school organizational competence elements. Finally, in Sect. 5, further work is discussed.

2 Background: Individual and Organizational Competence

2.1 Individual Competence

Competence is considered a key concept in the fields of human resources, education, etc. (Stoof et al. 2002). Yet, there exists a high level of proliferation of definitions for the concept (Sampson and Fytros 2008). Mirroring this diversity in definitions, a number of different approaches towards individual competence structural representation have been proposed. Some examples include the Iceberg model by Spencer and Spencer (1993), the concentric circle model by Rowe (1995), the five-element model by Cheetham and Chivers with its notion of meta-competences (Sultana 2009), the boundary approach by Stoof et al. (2002), the holistic approach by Le Deist and Winterton (2005) (also in Winterton 2009) and the tripartite representation by Sampson and Fytros (2008), with its explicit inclusion of context within the competence definition. For the purposes of this chapter, we adopt the latter for individual competence representation.

The last approach views individual competence as a set of three elements, namely: (1) the person's characteristics (i.e. their knowledge, attitudes and skills), (2) the competence proficiency level, which is used to evaluate the performance of the competence and (3) the context within which the competence is performed and evaluated. This notion of context is considered as vital by a number of researchers, since the level of proficiency of a specific competence is highly dependent on the context within which it is used (Cheetham and Chivers 2005; Wesselink and Wals 2011).

2.2 Organizational Competence

Apart from the individual strand, competence has also been identified as a characteristic of organizations. This standpoint is adopted in our work reported in this chapter, arguing towards a more holistic view of schools as organizations. This perspective deviates from the approach that views organizational competences as merely the sum of the individual staff competences, since a variety of other factors interplay and produce unique results, even with similar individual inputs (Rakickaite et al. 2011).

Fig. 19.1 Organizational concept representation

From this perspective, organizations are considered as "individual" entities that are competent in the specific fields they operate and in the tasks that they perform. Moreover, the high level of competence at organizational level is considered vital to their development (Harris 2007; Nogueira and Bataglia 2012) and constant evaluation of the actual outcome must be performed for remedying purposes (Dhillon 2008).

Before attempting to define organizational competence, we discuss various relevant concepts that are commonly used in an interchangeable manner. These include the organizational resources, capabilities and competences. Organizational *resources* form the foundational level of organizations upon which their functions are based (Javidan 1998; Zangiski et al. 2013). However, and despite the standpoints of the resource-based view (Gu and Jung 2013), it is claimed that these assets cannot guarantee organizational success in their own regard. It is the optimal combination and utilization of them that can offer that, i.e. the organizational *capabilities* (Martelo et al. 2013). Furthermore, organizational *competences* describe reified capabilities (routines) that have been well exercised and have led to measurable outcomes (OpenLearn 2006). If a specific competence is valued as vital to gaining a strategic advantage over the competitors and to fulfilling the desired goals, then it is described as core competence (Prahalad and Hammel 1990). Finally, the concept of *dynamic capabilities* describes the ability of an organization to continuously develop its competences by adapting to new circumstances (Sanchez 2004; Teece 2007) and, thus, tackling organizational inertia and engaging in organizational learning.

Figure 19.1 captures a representation of the different concepts from the above analysis that will draw a picture of their position within the organization (Javidan 1998; Bhamra et al. 2011; Zangiski et al. 2013).

After presenting these clarifications, a review of existing approaches for defining organizational competence was performed, in order to identify the foundational dimensions of the concept. Table 19.1 presents a summary of existing definitions for organizational competence. All these approaches either define competence explicitly, or use other terms in an interchangeable manner.

An analysis of the content of the above definitions provides indications on a set of recurring components. More specifically, three such components are identified, namely the organization's tangible resources, the organizational culture and the intangible assets owned by the organisation, i.e. the individual competences of the staff.

Figure 19.2 presents the number of appearances of each element in the definitions of Table 19.1. The definition that best incorporates these elements is the one by Taatila (2004), with the addition of aspects of the external environment, i.e. the stakeholders' perspective.

Table 19.1 Organizational competence definitions

	Paper	Organizational competence definition
1	Prahalad and Hamel (1990)	The collective learning in the organization, especially how to coordinate diverse production skills and integrate multiple streams of technologies
2	Grant (1991)	Capacity … to deploy existing resources to perform some task
3	Barney (1991)	The firm attributes that enable organizations to coordinate and utilize their resources
4	Amit and Schoemaker (1993)	A firm's capacity to deploy resources, usually in combination, using organizational processes, to effect a desired end. They are information-based tangible or intangible processes that are firm-specific and are developed over time through complex interactions among the firm's resources
5	Doz (1997)	Integrative task performance routines that combine resources (skills and knowledge, assets and processes, tangible and intangible) to result in superior competitive positions
6	Drejer (2000)	A system of technology, human beings, organisational (formal) and cultural (informal) elements and the interactions of these elements
7	Hendeghem and Vendermeulen (2000)	A sustainable competitive advantage by unique combination of skills, knowledge and abilities (SKAs) structures, management systems, technologies and procedures and personnel instruments
8	Maritan (2001)	An organization's capacity to deploy its assets, tangible or intangible, to perform a task or activity to improve the performance
9	Hafeez et al. (2002)	The ability to make use of resources to perform some task or activity
10	Helfat (2003)	An organisational ability to perform a coordinated task, utilizing organisational resources, for the purpose of achieving a particular end result
11	Murray and Donegan (2003)	Involve complex patterns of coordination between people, and between people and other resources that lead to sustainable competitive advantage over time
12	Sanchez (2004)	The ability to sustain the coordinated deployment of assets in ways that help a firm achieve its goals
13	Taatila (2004)	An organisation's internal capability to reach stakeholder-specific situation-dependent goals, where the capability consists of the situation-specific combination of all the possible individual-based, structure-based and asset-based attributes directly manageable by the organisation and available to the organization in the situation
14	Freiling (2004)	Organizational, repeatable, learning-based and therefore non-random ability to sustain the coordinated deployment of assets and resources enabling the firm to reach and defend the state of competitiveness and to achieve the goals
15	Spanos and Prastacos (2004)	Socially constructed entities organized in networks of knowledge carrying relations among individuals and inanimate firm assets that, as a whole, aim at performing efficiently and effectively a given task.

Table 19.1 (continued)

	Paper	Organizational competence definition
16	Gill (2006)	The embodied knowledge set that supports competitive advantage through innovation and flexibility gained by building alignment between the strategic intent, the organizational structure and the expertise of the workforce
17	Lejeune (2006)	Cognitive combinations of existing resources to be activated into new or existing activities so as to reach some targeted outcomes.
18	Ermilova and Afsarmanesh (2007)	The organization's capability to perform (business) processes, tasks, having the necessary resources (human, technological, physical) available, and applying certain standards (practices), with the aim to offer certain products and/or services
19	Edgar and Lockwood (2008)	A set of progressive, iterative understandings and skills held by corporate employees that collectively operate at the organizational level
20	Kraaijenbrink et al. (2010)	(Capabilities) enable the firm to select, deploy, and organize such inputs (the resources)
21	Rakickaite et al. (2011)	A whole of the potential of internal organizational competence and of external contextualized organizational competence. Internal organizational competence is belonging to employees at individual and collective levels and by an organization is held as important knowledge, skills, abilities, attitudes, values and other personal and collective properties, revealing the potential of organizational competence
22	Zangiski et al. (2013)	Constructs that mediate this relationship, that is, linking operations strategy to productive resources mobilization that contribute to operations strategic vision building

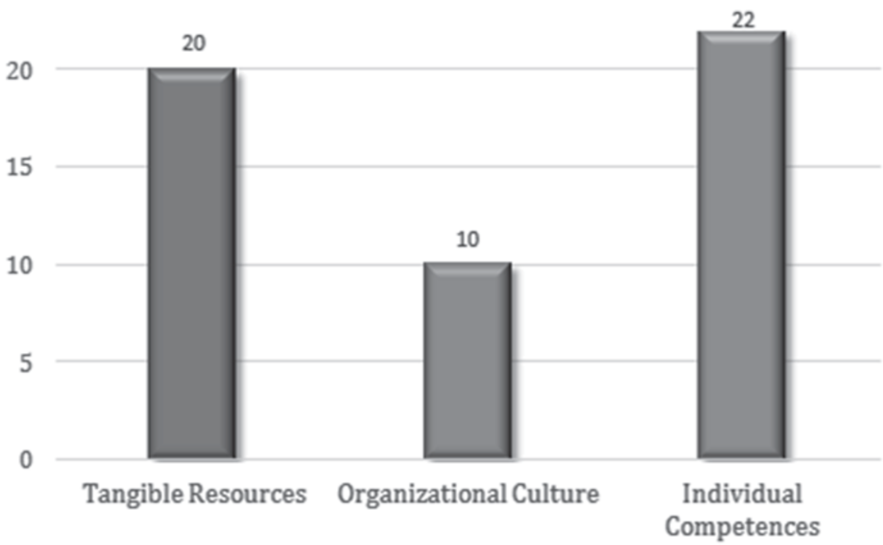


Fig. 19.2 Common elements' occurrence in organizational competence definitions

Therefore, the literature review presented in this section has highlighted the essential elements of organizational competences. This will be utilized for the review of the current approaches to measure ICT integration in schools (namely, eMaturity) and the identification of certain elements that, while being a foundational part of the organizational competence, are currently either insufficiently measured or totally neglected.

3 eMaturity and Evaluation Frameworks

The concept of eMaturity has been used to describe the level of ICT use in educational institutions (BECTA 2002). There are two different definitions for eMaturity in the literature. The first, provided by Durando et al. (2007), defines eMaturity as the institution's "strategic and effective use of ICT to improve educational outcomes". The second states that eMaturity is the "organizational readiness to deal with e-learning and the degree to which this is embedded in the curriculum" (Underwood et al. 2010). Both definitions share a common standpoint towards ICT integration, which views technology as being embedded in the educational institutions' processes, rather than just being used in an ad hoc basis from groups of capable individuals (Micheuz 2009). The former definition has a formative approach, linking ICT use, and its *strategic planning,* to educational outcome improvements. The latter appears to take a more summative standpoint dealing with the evaluation of the institution's existing ICT use and integration.

This dual perspective of eMaturity has spawned a diverse set of frameworks, which mirror these standpoints. An overview of these approaches is presented in the next section. Moreover, an analysis of the different frameworks' categories is performed in order to identify generic meta-categories that are linked to the eMaturity concept, in general. Finally, the latter are examined to identify the level to which they incorporate the elements of school organizational competence and, thus, the level of their sufficiency to accommodate the representation of all the interrelating factors influencing ICT uptake in schools.

3.1 eMaturity Frameworks

A literature review of scientific and "grey" literature revealed a set of existing frameworks for the measurement of the level of ICT integration in educational institutions. This process resulted in the identification of six frameworks adopting a whole-institutional perspective. These were the NAACE ICT-Mark (NAACE 2012), the P2P/P2V Inspectorates Framework (European Schoolnet 2009), the Digital Schools Award (Digital Schools of Distinction 2013), the ACODE Benchmarks (ACODE 2004), the E-Learning Maturity Model (eMM; Marshall 2007) and the ICTE-M Model (Solar et al. 2013). However, the latter was not fully described in the literature, therefore it could not be meaningfully analysed. An overview of these frameworks is provided in Table 19.2.

Table 19.2 Overview of eMaturity frameworks

	Name	Metric categories	Levels	Metrics
1	ICT-Mark	Leadership and management Curriculum planning Teaching and learning Assessment of ICT capability Professional development Resources	4	57
2	P2V	C1. Leadership C2. Pupil use C3. Impact on learning and standards C4. Infrastructure and access U1. The teaching process U2. Curriculum planning U3. Administrative use O1. Quality assurance	4	19
3	Digital Schools	Leadership and vision ICT in the curriculum School ICT culture Professional development Resources and infrastructure	2	50
4	ACODE	Institution policy and governance for technology-supported learning and teaching Planning for, and quality improvement of, the integration of technologies for learning and teaching Information technology infrastructure to support learning and teaching Pedagogical application of information and communication technology Professional/staff development for the effective use of technologies for learning and teaching Staff support for the use of technologies for learning and teaching Student training for the effective use of technologies for learning Student support for the use of technologies for learning	5	73
5	eMM	Learning Development Support Evaluation Organisation	4	35

As Table 19.2 depicts, among the existing frameworks, there is a number of recurring metric categories. In order to identify commonalities in these, a further analysis of the contents and focal points of each category was performed, in order to create a set of unifying, meta-categories. These are described in Table 19.3, along with their key focal points.

Table 19.3 eMaturity generic meta-categories

	Category	Main focal points	Framework (category)
1	Leadership for ICT	Existence of a vision for ICT integration Constantly evaluated strategy towards its achievement	ICT MARK (1) P2V (C1) Digital Schools (1) ACODE (1,3) eMM (5)
2	Curriculum planning/ ICT integration in curriculum	High level of ICT use within and beyond school Consistent ICT planning throughout the curriculum Planning for student inclusion Diverse opportunities for engagement with diverse and emerging ICT Focus on ICT competence building	ICT MARK (2) P2V (C3, U2) Digital Schools (2), ACODE (2,4) eMM (5)
3	ICT in learning and teaching processes	Manifold and multifaceted use of ICT during the processes Student inclusion Evidence of student ICT competence building	ICT MARK (3) Digital Schools (1,2) P2V (U1, U2, O1) ACODE (4,7) eMM (1)
4	ICT professional development	Opportunities for staff professional development are provided Diverse modes of delivery are promoted Professional development has a recorded impact on staff's competences	ICT MARK (5) Digital Schools (4) ACODE (5)
5	Infrastructure and resources	Existence and sufficiency of hardware and software Internal and external connectivity Existence of e-safety systems Appropriateness of resources' physical deployment	ICT MARK (6) Digital Schools (5) P2V (C2) eMM (2)
6	ICT support structures	Existence of support systems for staff and students	ICT MARK (6b) P2V (C2.3) ACODE (6, 8) eMM (3)

These meta-categories match at a high degree (and even extend) the generic eMaturity areas mentioned by Harrison et al. (2013), namely connectivity, curriculum ICT policy, school leadership and management planning for ICT and staff development. Similar generic areas have been mentioned by Luger (2007) and Davies and Pittard (2009).

There were two metric categories that were not included in the generic category pool. First, the Digital Schools Award includes a distinct "School Culture" element, but the constituting elements are not unique, meaning that they are represented in alternate categories of other frameworks. Because of this, and also because it was only mentioned in the Digital Schools framework, it was not included in the eMaturity generic categories' pool. Moreover, the eMM and the P2V included specific evaluation metric categories. However, it was not deemed as appropriate for an eMaturity generic category, since evaluation should be embedded within each category, as is the standpoint that the rest eMaturity frameworks take.

Table 19.4 Review of eMaturity frameworks against organizational competence dimensions

Framework	Individual ICT competences		Tangible assets	Organizational culture
	Teacher	Administrator		
ICT-Mark	×	✓	✓	✓
P2P–P2V	×	×	✓	×
eMM	×	×	✓	×
Digital Schools	×	✓	✓	×
ACODE	×	✓	✓	×
Generic categories	×	×	✓	×

✓ signifies full integration, × signifies insufficient integration

The following section presents a critical discussion on the level of sufficiency that the above metric categories offer in terms of adequate accommodation of the elements of school organizational competence, as defined in this chapter.

3.2 Review of the eMaturity Frameworks

The contents of each eMaturity framework, as well as the generic eMaturity categories as described in the previous section, were reviewed, in order to identify the level to which they provided sufficient encapsulation of the elements of organizational competence. This was performed, as aforementioned, with the aims of (1) identifying gaps in the existing ICT integration measurements processes and (2) proposing alternatives for accommodating these shortcomings.

The review process included a binary scale, namely "insufficiently" (if the framework incorporated metrics for an incomplete or non-existent representation of the element) or "fully" (if the element was sufficiently captured by the existing metrics). Concerning the organizational culture aspect, the School Work Culture Profile (SWCP; Snyder 1988) was selected for providing a basis for evaluation (see Sect. 4). Table 19.4 presents the results of this review.

As Table 19.4 depicts, of the four organizational competence elements (including sub-elements), only the tangible assets are universally and adequately represented by the existing frameworks. Moreover, a significant issue is the universal lack of a method for capturing teachers' ICT competences. The administrator competences are indirectly addressed in some cases under the "Leadership" eMaturity category, but these implementations do not provide a solid method for assessing which ICT competences an administrator or leader should possess in order to drive their school (with its unique competences) towards full ICT exploitation. The same rule applies to the "Organizational Culture" element.

The above issue of inadequate accommodation of the individual staff ICT competences (i.e. teachers and administrators) is deemed as crucial since these actors obviously play a vital part in the overall planning and delivery of the school's ICT vision and strategy. Therefore, their specific ICT competences should be explicitly taken into account when measuring the ICT competence level of schools. With the addition of appropriate frameworks for capturing these elements, schools can monitor not only the processes that these actors are involved in but also the level of their individual competence in carrying them out. The major added value could be the ability of schools to identify potential reasons for the reported level of competence in certain school function areas. For example, the eMaturity approach would state a fact that the school shows low level of ICT uptake in specific "teaching processes". However, without an explicit ICT competence profile of all the teachers who are planning and delivering the lessons, it would not be possible to identify that a group of teachers (who can be identified) lacks a specific set of necessary competences, a fact that ends up impeding the overall processes and school-wide strategies. Moreover, correlation analyses can be performed between the individual ICT competences of school actors and the overall school performance, in order to further enhance the level of overview that the school has on its function and its progress over time.

Apart from the explicit lack of representation for specific organizational competence elements, the content analysis of the existing frameworks highlighted two additional areas that could potentially hinder the effective measurement of school ICT uptake and the meaningful interpretation of the results. More specifically, despite the fact that the frameworks' categories can be semantically grouped in unified meta-categories, the fact that each framework uses diverse metrics for evaluating the same school area's ICT performance can prove to be a hindrance in the universal recognition of the results. This fact is further enhanced by the lack of a universal measurement scale in these approaches. Moreover, another issue is related to the fact that the interrelating factors affecting each metric are almost never identified. This shortcoming is related to the previously mentioned added value of utilizing staff ICT competence profiles. The identified issue is that schools can be aware of a general area where they underperform, but have no specific information on the exact sub-elements that hinder their performance, and, therefore, receive no guidance or suggestions on how to amend for it.

Finally, another issue (not related to framework content) that could hinder the existing frameworks' ability to enable school ICT improvement is related to the context within which they are used. More specifically, two frameworks (namely the ICT-Mark and the Digital Schools Award) take an explicit accreditation-oriented approach towards eMaturity. This means that they target on external, official inspection for providing accreditations. This fact, despite lending motivational boost for the participation of schools, may lead to window-framing situations where the actual reality in the school is hidden or there are targeted improvements only to the elements under inspection (Ossege 2012). In addition, school staff members have expressed their disapproval for this type of accountability to external bodies in favour of actual school improvement initiatives (Knapp and Feldman 2012).

In the light of all the above issues, it is evident that the current implementations of eMaturity do not offer robust metrics for capturing and evaluating key elements affecting the level of school ICT integration. Therefore, it is important to extend the current approaches in order to accommodate such improvements. To address this issue, and to allow for a more granulated, overall, evaluation method, an alternative approach has been developed and is presented in the following section.

More specifically, the proposed framework builds on the eMaturity frameworks, extending them for including the individual competences of the schools' staff and, also, providing more granulated metrics for all the areas, based on commonly used competence frameworks.

4 Proposal for a School ICT Competence Profiling Framework

As aforementioned, the proposed framework is based on the eMaturity frameworks but aims to extend them in order to incorporate essential elements of the school organizational competence as it was defined in this chapter, i.e. as a tridimensional entity. This approach aims for the representation of schools' ICT competences (and, potentially, educational organizations in general) in a detailed and unified manner, based on commonly used competence frameworks. The following sections present, in detail, each of the proposed framework's dimensions.

4.1 The Individual Competences Dimension

The individual competences of the school address the competences of the human actors, namely the teaching staff and the administrators. This dimension refers to the ICT competences that the individuals should possess in order to perform in a competent manner. This is a major addition which aims to tackle the significant lack of accommodation of such data from the existing approaches.

The competences related to this dimension are derived from existing individual competence frameworks. More specifically, the UNESCO ICT Competency Profile for Teachers (UNESCO 2011) is used for the teachers' ICT competences and the International Society for Technology in Education (ISTE) Standards for Administrators (ISTE 2009) for the administrators' ICT competences.

The UNESCO ICT Competency Profile for Teachers has been developed with the aim to assist teachers in using ICT for improving students' learning. It incorporates six competence categories, namely understanding ICT in education, curriculum and assessment, pedagogy, ICT, organization and administration and teacher professional learning. Furthermore, it defines three proficiency levels (or approaches), which are technology literacy, knowledge deepening and knowledge creation. The rationale for selecting this framework is its credibility, which is verified by the standing of the developing body and its wide scope and recognition (Zervas et al. in-press).

The ISTE Standards for Administrators have been developed by the International Society for Technology in Education with the aim to provide a set of competences needed by school administrators in order to be able to support digital age learning and transform the educational landscape. The standards include five areas, namely visionary leadership, digital age learning culture, excellence in professional practice, systemic improvement and digital citizenship. Each area is divided in a number of competences. The ISTE Standards for Administrators were used since they are the only identified framework addressing the subject of ICT competences of school administrators.

The proposed approach for representing individual ICT competences offers a commonly recognized, granulated and robust manner to capture significant elements of the school ecosystem that were currently either indirectly addressed or totally ignored. Also, it does not add a significant cost to the overall process, since these metrics can be self-administered.

4.2 The Tangible Assets Dimension

The tangible assets field will be populated with the infrastructure of the school. To the best of our knowledge, there is no existing model for capturing organizational infrastructure elements and, therefore, bearing in mind the adequate representation of this element from the majority of existing eMaturity approaches, a superset of these metrics was created. A content analysis was performed to identify overlapping elements and the resulting list was enhanced with items focused on the strictly quantitative capturing of certain aspects, e.g. the exact number of functional computers in the school.

The list comprises a set of eight categories related to the tangible assets of educational institutions. The metrics used aim to capture both actual data on the current infrastructural state and perceived data on the levels of use and efficiency of the different asset categories. The full composed list is presented in Table 19.5. Each metric is accompanied with the proposed value type for its population.

The added value of the proposed approach is that it offers a unifying and overarching metric set that encapsulates all the major focal points of the eMaturity frameworks. It can, therefore, allow for interoperable results that can be used for universal recognition of the schools' achievements.

5 The Organizational Culture Dimension

Regarding the school culture element, it was deemed important for inclusion in the proposed framework, since it was identified as a vital element of organizational competences, but was almost universally neglected from the eMaturity approaches. Additionally, the literature argues towards the school culture's importance for effective ICT integration in schools (Somekh 2008).

Numerous existing models for measuring organizational culture are available. A detailed review of this research area has been published by Jung et al. (2007). A

Table 19.5 Organizational tangible assets model

	Area	Framework	Metrics					
1	Hardware	ACODE, P2V Digital Schools ICTE-MM eMM	Place (*Item list*)	Type (*Item list*)	Number of functional devices (*value*)	Specifications (*value*)	Appropriate physical placement (*1..5*)	Access for teaching (*1..5*)
2	Software	ICT-Mark P2V eMM Digital Schools	Subject domain (*Item list*)	Number of functional pieces of software (*value*)	Title (*value*)	Up-to-date (*value*)	Sufficiency in terms of curriculum(*1..5*)	Access to all students (*1..5*)
3	Procurement strategy	ACODE P2V ICT-Mark eMM	Existence (*Y/N*)	Efficiency (*1..5*)	Specific and adequate budget (*1..5*)	Evaluation of school asset needs (*1..5*)	–	–
4	Connectivity	Digital Schools ICT-Mark	Type (*Item list*)	Existence (*Y/N*)	Connection Speed (*value*)	Access to all students (*1..5*)	Reliability (*1..5*)	–
5	Management system	ICT-Mark	Existence (*Y/N*)	Access to all stakeholders (*1..5]*)	Level of student administrative use (*1..5*)	Level of managerial use (*1..5*)	Efficiency (*1..5*)	–
6	E-learning spaces	P2V ICT-Mark Digital Schools	Existence (*Y/N*)	Access to all (1..5)	Level of teacher use (*1..5*)	Level of student use (*1..5*)	–	–
7	Safety systems	P2V ICT-Mark Digital Schools	Type (*Item list*)	Existence (*Y/N*)	Efficiency (*1..5*)	–	–	–
8	Technical support	ACODE P2V ICT-Mark eMM	Existence (*Y/N*)	Number of staff (*value*)	Sufficiency (*value*)	Availability (*1..5*)	Efficiency (*1..5*)	–

fraction of these focuses on the specific context of schools (Maslowski 2006). This small pool of candidates was considered for the purpose of identifying an appropriate model for the proposed framework for school ICT competences. The candidate models were:

- The Organizational Culture in Primary Schools (OCPS; Houtveen et al. 1996)
- The Schools Values Inventory Form III (SVI; Pang 1998)
- The School Cultural Elements Questionnaire (SCEQ; Cavanagh and Dellar 1996)
- The SWCP (Snyder 1988)
- The Professional Culture Questionnaire for Primary Schools (PCQPS; Staessens 1990)
- The School Culture Survey (SCS; Saphier and King 1985)
- The School Quality Management Culture Survey (SQMCS; Detert et al. 2003)

The process of selecting the most appropriate model for representing School Culture was facilitated by the work of Schoen and Teddie (2008), who identified four key elements that school culture conceptualizations should include. They were described as follows:

- "Professional Orientation", which incorporates the attitudes and activities that signify the level of professionalism in the faculty in terms of development and school improvement.
- "Organizational Structure", which includes aspects related to leadership type, levels of communication between staff, internal/external accountability and the development of common vision/mission for the school.
- "Quality of Learning Environment", which refers to the extent of opportunities provided by the school for students to engage in meaningful challenges. It must be noted that this dimension can be integrated in the premises of the UNESCO ICT Competency Framework for Teachers and, therefore, was not included in the selection process.
- "Student-centred focus", which incorporates the level of individual student needs' support and assessment.

These dimensions are a superset of similar ones proposed by Zhu et al. (2011).

The aforementioned dimensions of school culture were used as a basis for evaluating the candidate models against. In addition to these criteria, the latter had to clearly adopt an entire school perspective. Under this light, a set of models did not qualify and had to be eliminated from the list. These were the SCS and the SCEQ, which were mainly focused on teachers. Moreover, the SQMCS model was not included due to the low validity (Cronbach's alpha) associated to its elements (Detert et al. 2003).

The results of the comparison of the remaining four candidate models are presented in Table 19.6.

As Table 19.6 depicts, "Professional Orientation" and "Organizational Structure" are elements that are almost universally present in the candidate models. On

Table 19.6 Comparison of school culture frameworks

	Model	Validity (Cronbach's alpha)	Dimensions of organizational culture		
			Professional orientation	Organizational structure	Student-centred focus
1	SWCP	0.88–0.97	✓	✓	✓
2	PCQPS	0.89–0.95	×	✓	×
3	SVI	0.73–0.92	✓	✓	×
4	OCPS	0.70–0.89	✓	✓	×

✓ signifies full incorporation and × signifies no incorporation

the other hand, the "Student-centred focus" element is only adequately represented by the SWCP model. Moreover, the SWCP model has been reported to have a high validity coefficient.

As a result of the above, the SWCP model was identified as the most appropriate for inclusion in the proposed framework. The model consists of four domains, namely "School-wide Planning", "Professional Development", "Program Development" and "School Assessment", each comprising 15 metrics (for a detailed analysis, see Quin 2012). The model's areas and metrics cover a wide range of school functions, including intra-staff relationships and collaboration, hierarchical communication, school-wide planning and, even, provide for the inclusion of parents in these processes. For these reasons, and the fact that it boasts a very high level of validity, this model was deemed as the most appropriate for incorporation in the proposed school ICT competence profiling framework.

6 Discussion and Future Work

This chapter presented a proposal for a unified school ICT competence profiling framework (Fig. 19.3).

This proposal was based on a literature review on the concept of competence, both at the individual and organizational level, and a critical evaluation of the existing approaches towards the measurement of ICT integration levels in educational institutions. This process highlighted a set of shortcomings, the most significant of which were the lack of robust and explicit methods for capturing the ICT competences of key elements of the school ecosystem. This is an important drawback, since it can significantly hinder the organization's ability to identify factors that impede the progress of its strategic ICT planning, as well as its capacity for effective future planning. Therefore, the proposed framework takes a step towards addressing these drawbacks and providing a more detailed basis for schools to engage in effective capturing, monitoring and evaluation of their ICT competences.

With the presented framework as a starting point, future work could include the creation of a formal specification for capturing school organizational compe-

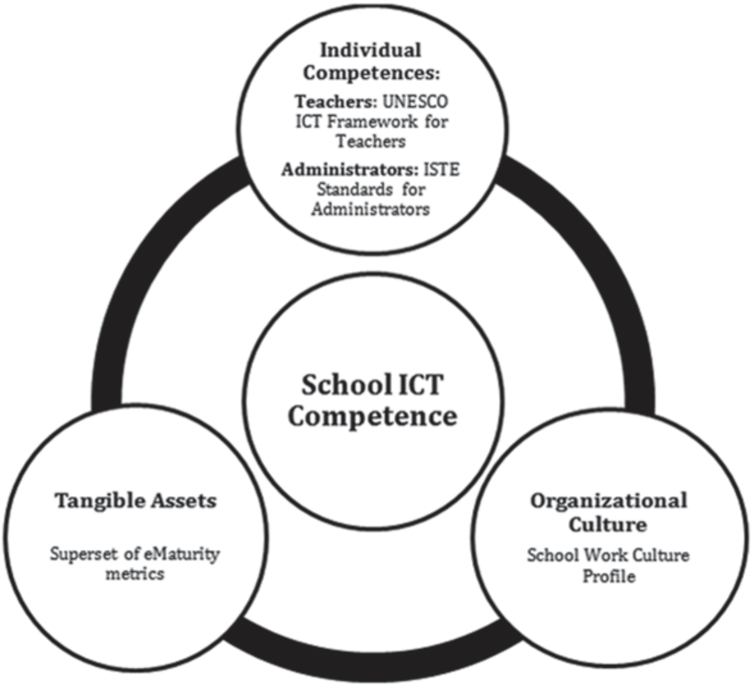


Fig. 19.3 Overview of the School ICT Competence Profiling Framework

tences in a machine-readable manner, correspondingly to the HR-XML (HR-XML 2006) or InLOC (Hoel and Grant 2013) specifications used for individual competences. This should include ontologies' linking specific competences within each sub-framework of the school ICT competence profile (e.g. specific teachers' competences with organizational culture competences), with the aim of creating mapping rules to highlight the manner in which these elements interrelate. This could pave the way for the development of tools that will enable schools to dynamically capture, monitor and update their ICT competences by utilizing existing technologies such as learning analytics and recommender systems. Moreover, the output of these processes could be used for remedying purposes, e.g. for creating specific and targeted recommendations for improving areas possessing a low level of ICT competence.

Therefore, in general, this approach has the potential to offer not only a detailed and highly granulated means of capturing the current level of ICT usage at school level, but also, and perhaps more importantly, a clearer view of the exact elements of school function that hinder the overall development of the institution and, thus, assist in constructing targeted corrective paths.

References

ACODE. (2004). ACODE Benchmarks. http://acode.edu.au/pluginfile.php/107/mod_page/content/2/ACODE_benchmarks.pdf. Accessed 2 Dec 2013.

Amit, R., & Schoemaker, P. J. (1993). Strategic assets and organizational rent. *Strategic management journal, 14*(1), 33–46.

Barney, J. (1991). Firm resources and sustained competitive advantage. *Journal of Management, 17*(1), 99–120.

BECTA (2002). ICT supporting teaching: Developing effective practice. http://homepages.shu.ac.uk/~edsjlc/ict/becta/effective_practice.pdf. Accessed 25 Nov 2013.

Bhamra, R., Dani, S., & Bhamra, T. (2011). Competence understanding and use in SMEs: A UK manufacturing perspective. *International Journal of Production Research, 49*(10), 2729–2743.

Cavanagh, R. F., & Dellar, G. B. (1996). *School cultural elements questionnaire*. Unpublished PhD Dissertation, Curtin University, Perth.

Cheetham, G., & Chivers, G. (2005). *Professions, competence, and informal learning*. Cheltenham: Edward Elgar.

Davies, S., & Pittard, V. (2009). Harnessing technology review 2009. The role of technology in education and skills. http://dera.ioe.ac.uk/1422/1/becta_2009_htreview_report.pdf. Accessed 3 Dec 2013.

Detert, J. R., Schroeder, R. G., & Cudeck, R. (2003). The measurement of quality management culture in schools: Development and validation of the SQMCS. *Journal of Operations Management, 21*(3), 307–328.

Dhillon, G. (2008). Organizational competence for harnessing IT: A case study. *Information & Management, 45*(5), 297–303.

Digital School of Distinction. (2013). Digital schools of distinction. http://www.digitalschools.ie/criteria/. Accessed 2 Dec 2013.

Doz, Y. (1997). Managing core competeney for corporate renewal: Towards a managerial theory of core competeneies. In A. Campbell & K. Sommers Luchs (Eds.), Core competency-based strategy (pp. 53–75). London: International Thompson Business.

Drejer, A. (2000). Organisational learning and competence development. *The Learning Organization, 7*(4), 206–220.

Duncan-Howell, J. (2010). Teachers making connections: Online communities as a source of professional learning. *British Journal of Educational Technology, 41*(2), 324–340.

Durando, M., Blamire, R., Balanskat, A., & Joyce, A. (2007). *E-mature schools in Europe. Insight-Knowledge building and exchange on ICT policy and practice*. Brussels: European Schoolnet.

Edgar, W. B., & Lockwood, C. A. (2008). Organizational competencies: Clarifying the construct. *Journal of Business, 22,* 21–32.

Ermilova, E., & Afsarmanesh, H. (2007). Competency and profiling management in virtual organization breeding environments. In L. M. Camarinha-Matos, H. Afsarmanesh, & M. Ollus (Eds.), *Network-centric collaboration and supporting frameworks* (pp. 131–142). NY: Springer.

European Commission. (2010). Learning, innovation and ICT. Lessons learned by the ICT cluster Education & Training 2010 programme. http://www.icde.org/filestore/Resources/Reports/KeyLessonsICTclusterReport.pdf. Accessed 15 Jan 2014.

European Commission. (2013). Survey of schools: ICT in education. http://ec.europa.eu/digital-agenda/sites/digital-agenda/files/KK-31-13-401-EN-N.pdf. Accessed 28 Nov 2013.

European Commission/EACEA/Eurydice. (2012). Developing key competences at school in Europe: Challenges and opportunities for policy. Eurydice Report. Luxembourg: Publications Office of the European Union. http://eacea.ec.europa.eu/education/eurydice/documents/thematic_reports/145EN.pdf. Accessed 5 Jan 2014.

European Schoolnet. (2009). Learning from each other: the p2v project on ict and school change. http://peerlearning.eun.org/shared/data/pdf/p2v_book_final.pdf. Accessed 1 Jan 2014.

Eurydice. (2011). Key data on learning and innovation through ICT at school in Europe 2011. Education, Audiovisual and Culture Executive Agency. http://eacea.ec.europa.eu/education/eurydice/documents/key_data_series/129en.pdf. Accessed 2 Jan 2014.

Freiling, J. (2004). A competence-based theory of the firm management revue. *The International Review of Management Studies, 15*(1), 27–52.

Gill, L. M. (2006). *Building organisational capability*. PhD Dissertation, Queensland University of Technology.

Grant, R. (1991). The resource-based theory of competitive advantage: Implications for strategy. *California Management Review, 33,* 114–135.

Gu, J. W., & Jung, H. W. (2013). The effects of IS resources, capabilities, and qualities on organizational performance: An integrated approach. *Information & Management, 50,* 87–97.

Hafeez, K., Zhang, Y., & Malak, N. (2002). Determining key capabilities of a firm using analytic hierarchy process. *International Journal of Production Economics, 76*(1), 39–51.

Harris, R. (2007). Unravelling the notion of organisational capability: What do writers say it is and VET providers think it is? PhD dissertation, AVETRA.

Harrison, C., Tomás, C., & Crook, C. (2013). An e-maturity analysis explains intention-behavior disjunctions in technology adoption in UK schools. *Computers in Human Behavior*, (In Press).

Helfat, C. E. (2003). Stylized facts regarding the evolution of organizational resources and capabilities. In C. E. Helfat (Ed.), *The SMS Blackwell handbook of organizational capabilities: Emergence, development, and change* (pp. 1–11). Malden: Blackwell.

Hendeghem, A., & Vendermeulen, F. (2000). Competency management in the Flemish and Dutch civil service. *The International Journal of Public Sector Management, 13*(4), 342–353.

Hoel, T., & Grant, S. (2013). Integrating learning outcomes and competences. http://wiki.teria.no/display/inloc/Scope+of+the+Model. Accessed 15 Nov 2013.

Houtveen, A. A. M., Voogt, J. C., Van der Vegt, A. L., & Van de Grift, W. J. C. M. (1996). *These are our manners: Research into the organizational culture of schools*. Utrecht: ISOR.

HR-XML (2006). HR-XML consortium competencies schema (measurable characteristics). http://www.cen-ltso.net/main.aspx?put=1060. Accessed 1 Dec 2013.

ISTE (2009). Standards for administrators. http://www.iste.org/docs/pdfs/nets-a-standards.pdf?sfvrsn=2. Accessed 30 Nov 2013.

Javidan, M. (1998). Core competence: What does it mean in practice? *Long range planning, 31*(1), 60–71.

Jung, T., Scott, T., Davies, H. T. O., Bower, P., Whalley, D., McNally, R., et al. (2007). Instruments for the exploration of organisational culture. http://www.scothub.org/culture/instruments.html. Accessed 15 Nov 2013.

Knapp, M., & Feldman, S. (2012). Managing the intersection of internal and external accountability: Challenge for urban school leadership in the United States. *Journal of Educational Administration*, *50*(5), 666–694.

Kraaijenbrink, J., Spender, le., & Groen, A. J. (2010). The resource-based view: A review and assessment of its critiques. *Journal of Management, 36*(1), 349–372.

Laurillard, D. (2007). Modelling benefits-oriented costs for technology enhanced learning. *Higher Education, 54*(1), 21–39.

Law, N., & Chow, A. (2008). Teacher characteristics, contextual factors, and how these affect the pedagogical use of ICT. In N. Law, W. J. Pelgrum, & T. Plomp (Eds.), *Pedagogy and ICT use*: In Schools Around the World Findings from the IEA Sites 2006 Study (pp. 181–219). Dordrecht: Springer.

Le Deist, F., & Winterton, J. (2005). What is competence? *Human Resource Development International, 8*(1), 27–46.

Lejeune, C. (2006). Organizational learning and capabilities: An integrative conceptual framework. www.uclouvain.be/cps/ucl/doc/iag/documents/WP_6_Lejeune.pdf. Accessed 5 Nov 2013.

Luger, J. (2007). NIACE report: Supporting the journey towards E-Maturity. http://archive.excellencegateway.org.uk/media/ferl_and_aclearn/acl/pages/leadership/fundingeshift_reports/Eshift_final_report_niace.pdf. Accessed 30 Nov 2013.

Maritan, C. A. (2001). Capital investment as investing in organizational capabilities: An empirically grounded process model. *Academy of Management Journal, 44,* 513–531.
Marshall, S. (2007). E-Learning maturity model: Process descriptions. www.utdc.vuw.ac.nz/research/emm/documents/versiontwothree/20070620ProcessDescriptions.pdf. Accessed 1 Dec 2013.
Martelo, S., Barroso, C., & Cepeda, G. (2013). The use of organizational capabilities to increase customer value. *Journal of Business Research, 66*(10), 2042–2050.
Maslowski, R. (2006). A review of inventories for diagnosing school culture. *Journal of Educational Administration, 44*(1), 6–35.
Micheuz, P. (2009). *E-Maturity and school development: When the tail wants to wag the Ddog. In Education and Technology for a Better World* (pp. 129–137). Berlin: Springer.
Murray, P., & Donegan, K. (2003). Empirical linkages between firm competencies and organizational learning. *The Learning Organization, 10*(1), 51–62.
NAACE. (2012). Naace: Self-review framework. http://www.naace.co.uk/ictmark/srf. Accessed 1 Dec 2013.
Nachmias, R., Mioduser, D., Cohen, A., Tubin, D., & Forkosh-Baruch, A. (2004). Factors involved in the implementation of pedagogical innovations using technology. *Education and Information Technologies, 9*(3), 291–308.
Nogueira, A. C., & Bataglia, W. (2012). Transaction costs and organizational competences: Explaining the governance structure for manufacturing stage. *Journal of Technology Management & Innovation, 7*(1), 159–174.
OpenLearn. (2006). Understanding organisational capabilities. http://www.open.edu/openlearn/money-management/management/human-resources/strategic-view-performance/content-section-3.1. Accessed 15 Nov 2013.
Ossege, C. (2012). Accountability-are we better off without it? An empirical study on the effects of accountability on public managers' work behaviour. *Public Management Review, 14*(5), 585–607.
Pang, N. S. K. (1998). The binding forces that hold school organizations together. *Journal of Educational Administration, 36*(4), 314–333.
Pelgrum, W. J. (2008). School practices and conditions for pedagogy and ICT. In N. Law, W. J. Pelgrum, & T. Plomp (Eds.), *Pedagogy and ICT use in schools around the world. Findings from the IEA SITES 2006 study* (pp. 67–121). Hong Kong: Springer.
Prahalad, C. K., & Hamel, G. (1990). *The core competence of the corporation. Harvard Business Review, 68*(3), 79–91.
Quin, W. A. (2012). *A comparison of the perceptions of school work culture by administrators and faculty in the public charter and non-charter elementary schools of a Central Florida County*. PhD Dissertation, University of South Florida.
Rakickaite, J., Juceviciene, P., & Vaitkiene, R. (2011). Structure of professional service firm's organizational competence. *Social Sciences, 73*(3), 51–61.
Rowe, C. (1995). Clarifying the use of competence and competency models in recruitment, assessment and staff development. *Industrial and Commercial Training, 27*(11), 12–17.
Sampson, D., & Fytros, D. (2008). Competence models in technology-enhanced competence-based learning. In Adelsberger, H. H., Kinshuk, Pawlowski, J. M. & Sampson, D. G. (Eds.), *International Handbook on Information Technologies for Education and Training* (2nd Ed., pp. 155–177). Berlin: Springer.
Sanchez, R. (2004). Understanding competence-based management: Identifying and managing five modes of competence. *Journal of Business Research, 57*(5), 518–532.
Sang, G., Valcke, M., van Braak, J., & Tondeur, J. (2010). Student teachers' thinking processes and ICT integration: Predictors of prospective teaching behaviors with educational technology. *Computers & Education*, *54*(1), 103–112.
Saphier, J., & King, M. (1985). Good seeds grow in strong cultures. *Educational Leadership, 42*(6), 67–74.
Schoen, L. T., & Teddlie, C. (2008). A new model of school culture: A response to a call for conceptual clarity. *School Effectiveness and School Improvement, 19*(2), 129–153.

Snyder, K. J. (1988). *School work culture profile*. Tampa: School Management Institute.
Solar, M., Sabattin, J., & Parada, V. (2013). A maturity model for assessing the use of ICT in school education. *Educational Technology & Society, 16*(1), 206–218.
Somekh, B. (2008). Factors affecting teachers' pedagogical adoption of ICT. In Voogt, J., & Knezek, G. (Eds.), *International handbook of information technology in primary and secondary education* (pp. 449–460). Springer US.
Spanos, Y. E., & Prastacos, G. (2004). Understanding organizational capabilities: Towards a conceptual framework. *Journal of Knowledge Management, 8*(3), 31–43.
Spencer, L. M., & Spencer, S. M. (1993). *Competence at work: Models for superior performance*. New York: Wiley.
Staessens, K. (1990). Professional culture of innovating primary schools: Empirical research in V.L.O.-schools. Unpublished PhD Dissertation, Katholieke Universiteit Leuben, Leuven.
Stoof, A., Martens, R. L., Van Merriënboer, J. J. G., & Bastiaens, T. J. (2002). The boundary approach of competence: A constructivist aid for understanding and using the concept of competence. *Human Resource Development review, 1,* 345–365.
Sultana, R. G. (2009). Competence and competence frameworks in career guidance: Complex and contested concepts. *International Journal For Educational And Vocational Guidance, 9*(1), 15–30.
Taatila, V. (2004). The concept of organizational competence: A foundational analysis. PhD dissertation. University of Jyväskylä.
Teece, D. J. (2007). Explicating dynamic capabilities: The nature and microfoundations of (sustainable) enterprise performance. *Strategic Management Journal, 28*(13), 1319–1350.
Tondeur, J., Coopert, M., & Newhouse, C. P. (2010). From ICT coordination to ICT integration: A longitudinal case study. *Journal of Computer Assisted Learning, 26*(4), 296–306.
Underwood, J., Baguley, T., Banyard, P., Dillon, G., Farrington-Flint, L., Hayes, M., & Selwood, I. (2010). Understanding the impact of technology: Learner and school level factors. http://oro.open.ac.uk/34529. Accessed 20 Nov 2013.
UNESCO. (2011). ICT competency framework for teachers. http://unesdoc.unesco.org/images/0021/002134/213475E.pdf. Accessed 2 Dec 2013.
Wesselink, R., & Wals, A. (2011). Developing competence profiles for educators in environmental Education organisations in the Netherlands. *Environmental Education Research, 17*(1), 69–90.
Winterton, J. (2009). Competence across Europe: Highest common factor or lowest common denominator? *Journal of European Industrial Training, 33*(8,9), 681–700.
Zangiski, M. A. D. S., de Lima, E. P., & da Costa, S. E. G. (2013). Organizational competence building and development: Contributions to operations management. *International Journal of Production Economics, 144*(1), 76–89.
Zervas, P., Chatzistavrianos, K., & Sampson, D. (In-press). Modelling ICT teachers' competences profile. In R. Huang, Kinshuk, & J. K. Price (Eds.), ICT in education in global context: Emerging trends 2013–2014. Springer.
Zhao, Y., & Frank, K. A. (2003). Factors affecting technology uses in schools: An ecological perspective. *American educational research journal, 40*(4), 807–840.
Zhu, C., Devos, G., & Li, Y. (2011). Teacher perceptions of school culture and their organizational commitment and well-being in a Chinese school. *Asia Pacific Education Review, 12*(2), 319–328.

Chapter 20
I²Flex: The Meeting Point of Web-Based Education and Innovative Leadership in a K–12 International School Setting

Maria D. Avgerinou, Stefanos Gialamas and Leda Tsoukia

1 Introduction

> If we teach today's students as we taught yesterday's, we rob them of tomorrow.
> John Dewey

As Bob Pearlman, one of the key leaders in USA's educational reform, points out (2010), a casual walk into any new brick-and-mortar schools across the USA reveals that despite the elaborate architectural designs and the wiring for educational technology integration, classrooms remain designed for teachers to stand in front of the students, thus still reflecting schooling as invented in the nineteenth century. Since those bygone and long past times however, the world has developed in such diverse directions and created new and particularly complex demands for citizenship, college, and careers that it is no longer possible for old learning environments associated with old learning paradigms to accommodate them. Indeed, "we are on the threshold of a tipping point in public education" (Kay 2010, p. xiii).

The recognition of the new reality has led to the development of a new vision for twenty-first-century learning. In 2010, Dede reported that current conceptual frameworks for twenty-first-century skills included the Partnership for 21st Century Skills (2006), the North Central Regional Education Laboratory (NCREL) and the Metiri Group (2003), the Organization for Economic Co-operation and Development (OECD 2005), and the National Leadership Council for Liberal Education and America's

M. D. Avgerinou (✉)
American Community Schools Athens, 129 Aghias Paraskevis Str.,
152 34 Halandri, Athens, Greece
e-mail: avgerinoum@acs.gr

S. Gialamas
American Community Schools Athens, 129 Aghias Paraskevis Str.,
152 34 Halandri, Athens, Greece
e-mail: gialamas@acs.gr

L. Tsoukia
ACS Athens, 4 Voutsina St, 156 69 Papagou, Athens, Greece
e-mail: lt@ltdesign.gr; ledatsoukia@gmail.com

D. G. Sampson et al. (eds.), *Digital Systems for Open Access to Formal and Informal Learning*,
DOI 10.1007/978-3-319-02264-2_20,

Promise (LEAP 2007). The Partnership for the 21st Century Skills framework (2006, 2009) is the most detailed and widely adopted of all aforementioned. It emphasizes that in addition to core subject knowledge, such skills as information and communication, inter-personal and self-directional, as well as being well versed with the technologies of this millennium, both from the consumer and the creator's standpoints, are critical in order to prepare students as lifelong learners to deal successfully with the demands of the ever-changing world of the postindustrial era of information revolution.

To successfully overcome the complexity of connecting the digital dots of today's world which "are multidimensional of varying sizes and colors, continuously changing, and linked to other, as yet unimagined dots" (Jones-Kavalier and Flannigan 2008, p. 14); to assimilate information's new set of characteristics (Jakes and Brennan 2006), namely digital, networked, overwhelming, immediate, manipulatable, participatory, and visual; to implement the change of learning brought about by the participatory media, from the Cartesian view (where knowledge was perceived as some type of "substance" that pedagogy would transmit) to the social view of learning ("we participate therefore we are"; Brown and Adler 2008); and to redefine the overcrowded curriculum of the past century in alignment with the demands of the new era, the Business and Higher Education Forum (2005) has proposed that workers of the twenty-first century must be educated toward developing science and mathematics skills, creativity, information and communication technologies (ICT) skills, as well as the ability to solve complex problems. Jenkins (2007) expanded the definition of the twenty-first-century skills to include:

- *Play*: the capacity to experiment with one's surroundings as a form of problem solving
- *Performance*: the ability to adopt alternative identities for the purpose of improvisation and discovery
- *Simulation*: the ability to interpret and construct dynamic models of real-world processes
- *Appropriation*: the ability to meaningfully sample and remix media content
- *Multitasking*: the ability to scan one's environment and shift focus as needed to salient details
- *Distributed Cognition*: the ability to interact meaningfully with tools that expand mental capacities
- *Collective Intelligence: the ability to pool knowledge and compare notes with others toward a common goal*
- *Judgment*: the ability to evaluate the reliability and credibility of different information sources
- *Trans-media Navigation*: the ability to follow the flow of stories and information across multiple modalities
- *Networking*: the ability to search, synthesize, and disseminate information
- *Negotiation*: the ability to travel across diverse communities, discerning and respecting multiple perspectives, and grasping and following alternative norms

These learning outcomes not only necessitate schools to seriously invest in, and systematically capitalize on the affordances of new technologies, but also to utilize more learner-centric pedagogies with specific focus on the newly emerged, idiosyncratic profile of the *digital learner*—a term coined by Prensky (2001) to describe today's students who have (Corrin et al. 2011; Oblinger and Oblinger 2005; Dede 2005; Prensky 2001):

- A high digital aptitude
- A preference for multitasking
- Literacy across multiple media
- A culture for sharing information
- A need for speed of information delivery
- A desire to be constantly connected

The various questions, challenges, and opportunities resulting from the educational reform and its many facets as described above have been addressed via groundbreaking research experiments such as Sugata Mitra's "a hole in the wall" (Mitra 2005) and ensuing first School in the Cloud (Newcastle University 2013); entire nations' movements toward innovative teaching and learning programs such as Singapore's initiative "Teach Less, Learn More" (Fogarty and Pete 2010); pressing demands for major policy changes (Darling-Hammond 2010); and, a continuous dialogue among leading educational thinkers about the significant role of creativity in today's education (Robinson 2001) and the forthcoming sovereignty of the right brain (Pink 2006) or of the five minds, per Gardner's (2010) suggestion.

At the same time, an unprecedented growth and firm establishment of online and blended learning at all levels of education, including various forms of virtual schooling in the K–12 sector (Davis and Niederhauser 2007; Rice 2012; Watson et al. 2010), has been witnessed. Indeed, online (and blended) learning has been saluted as the *disruptive force* that can transform the factory-like structure of today's educational institutions. Clayton Christensen, a Harvard Business School professor who coined the term of art *Disrupting Innovation* (Christensen et al. 2011), argues that by 2019, 50% of all high school courses will be delivered online.

This projection may seem less bizarre upon close inspection of current facts and figures pertaining to online and blended learning in the USA:

- The number of students taking at least one online course has now surpassed 6.7 million (sloanconsortium.org 2013).
- By 2013, that number will increase to 18.65 million.
- Half of the 4,500 brick-and-mortar colleges in the USA offer their degree programs online.
- Ninety-six percent of the traditional universities offer at least one class in an online-only format.
- OpenCourseWare offers 4,200 complete courses online for free.
- Of these courses, 1,689 are classes from Massachusetts Institute of Technology (MIT; source: ClassesAndCareers.com 2013).
- According to a 2009 study from the Department of Education: "Students who took all or part of their class online performed better, on average, than those taking the same course through traditional face-to-face instruction." Students who mix online learning with traditional coursework (i.e., blended learning) do even better (Internet Time Group Report 2013).

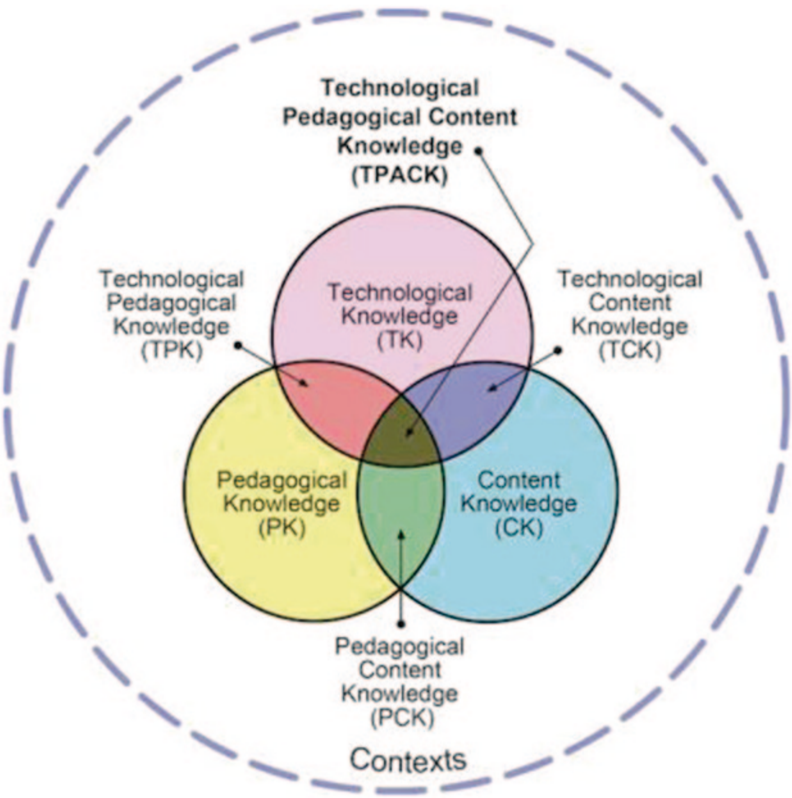


Fig. 20.1 The TPACK image. (Reproduced by permission of the publisher, © 2012 by tpack.org)

It thus comes as no surprise that a new framework has been developed to accommodate, determine, and reflect the critical role of technology into the teaching and learning process with the view to holistically address the curricular and pedagogical needs of any learning experience. Presented by Mishra and Koehler (2006, Koehler and Mishra 2008), the Technological Pedagogical Content Knowledge (TPACK) is a framework that identifies the types of knowledge that are necessary for teachers to teach effectively with technology (Fig. 20.1). The TPACK framework builds upon and extends Shulman's idea (1986, 1987) of Pedagogical Content Knowledge (PCK).

According to the authors, the TPACK framework is grounded on

> the complex interplay of three primary forms of knowledge: Content (CK), Pedagogy (PK), and Technology (TK). The TPACK approach goes beyond seeing these three knowledge bases in isolation. TPACK also emphasizes the new kinds of knowledge that lie at the intersections between them, representing four more knowledge bases applicable to teaching with technology: Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), and the intersection of all three circles, Technological Pedagogical Content Knowledge (TPACK). (http://www.tpack.org)

In fact, the authors go on to posit that the aforementioned components

> exist in a state of dynamic equilibrium or, as the philosopher Kuhn (1977) said in a different context, in a state of "essential tension"…. Viewing any of these components in isolation from the others represents a real disservice to good teaching. Teaching and learning with technology exist in a dynamic transactional relationship (Bruce 1997; Dewey and Bentley 1949; Rosenblatt 1978) between the three components in our framework: a change in any one of the factors has to be "compensated" by changes in the other two. (Mishra and Koehler 2006, p. 1029)

2 The Educational Paradigm Of Morfosis

As has been noted earlier, educating learners for their lives as twenty-first-century leaders requires us to create a new education paradigm. The American Community Schools of Athens (ACS Athens), Greece, a K–12 international school, is cognizant of the fact that traditional schooling is not the only avenue for learning. How could it be, since the reality is that students learn in different ways, via different modalities and styles, at a different pace in environments immersed in new technologies? The school is also a strong supporter of the notion of complete alignment among school learning outcomes and university and market needs. As a result, the school has generated its own education paradigm named *Morfosis* (Gialamas and Pelonis 2009)—a central tenet of Classical Greek experience—defined within the twenty-first-century framework as a holistic, meaningful, and harmonious educational experience, guided by ethos.

Holistic means understanding and successfully combining the academic, emotional, physical, intellectual, and ethical components to ensure a healthy, balanced individual, an individual who will successfully cope with the changes involved when entering higher education as well as the changes that life brings.

Meaningful refers to being in line with one's principles and values, with one's personal and professional goals. The educational experience must be meaningful for the learner. The learner should see it as part of his/her life and not in isolation of knowledge. In addition, it must be meaningful in relation to his/her dreams, strengths, desires, and talents. Discovering the feeling of being "in love with life and learning" gives life meaning and thus there is a personal interest in making "living" desirable.

Harmonious refers to the idea that all human dimensions must be in harmony. In other words, emotions, intelligence, and intellect must be harmonically integrated. Similar to an orchestra, working in harmony with the conductor is essential the learner is the conductor, the one who helps all parts stay in harmony. He in turn is the decision maker and the decision maker is the analytical thinker, reflector, mentor, teacher, and servant.

Ethos means **"**Doing the right thing when no one is watching you" (definition by a fifth-grade ACS Athens student).

3 The Aristeia Leadership

To successfully implement Morfosis, ACS Athens has strived to operate on innovative leadership (Gialamas 2011; Pelonis and Gialamas 2010). Innovative leadership is the continuous act of effectively engaging all members of the institution, as well as utilizing their differences, authentic energies, creative ideas, and diverse qualities primarily for the benefit of the students and also for every other constituency of the institution. This type of leadership has three dimensions:

- Interpersonal
- Setting standards
- Serving humanity

It also includes the following stages:

- Establishing a partnership based on common principles, values, and complementary personal and professional skills
- Distributing authority and decision making
- Outlining clearly the type, magnitude, and areas of authority
- Supporting and encouraging team members in using their authority
- Reflecting continuously on the partnership in order to adjust the distribution accountabilities and authority

Aristeia Leadership is the evolution of "innovative leadership" and it is defined as the authentic leadership identity (ALI) shaped by life experiences and the individual characteristics of the leader.

The process of understanding where one comes from and how different experiences in life have affected and influenced their personalities and shaped their character is important in developing and defining a leadership identity. Therefore, knowing oneself is the necessary first step in creating the leadership vision and defining its underlying philosophy of education.

Within this personality framework, one must then clearly identify their principles and values, knowing very well which are absolutely nonnegotiable. The next step consists of articulating a well-defined set of personal and professional goals through a similar process of self-reflection and revision.

Finally, working on establishing a leadership identity, the leader must adopt a holistic approach to life by ensuring that personal and professional goals align and do not conflict with, or undermine, one another.

Within the aforementioned leadership framework, the *Morfosis Educational Structure* is defined as the individually and collectively inseparable, inter-depending, and intra-depending trifold entity as depicted in the trefoil knot figure (Fig. 20.2):

a. The Morfosis educational paradigm
b. i^{2}Flex delivery methodology
c. The Aristeia leadership

Fig. 20.2 ACS Athens educational structure: Morfosis and its dimensions

4 i^{2}Flex: Delivering and Shaping Morfosis

The vehicle to implement Morfosis is the *i^{2}Flex* (isquareFlex), a non-traditional learning methodology organically developed by the ACS Athens community of learners. The i^{2}Flex methodology integrates Internet-based delivery of content and instruction with faculty-guided, student independent learning, in combination with face-to-face classroom instruction aiming at developing higher-order cognitive skills within a learning design framework that is flexible in terms of time, pace, place, and/or mode. This learner-centered type of learning draws on the research and practice of blended learning and the concept of "flipped classroom" in K–12 across the USA and beyond. Ultimately, i^{2}Flex aims at developing students' twenty-first-century skills, while also helping them successfully prepare for their higher education studies—where a good deal of the classes are already offered online—and their future careers.

More specifically, the i^{2}Flex methodology consists of a blend of face-to-face and web-based teaching and learning experiences. The web-based component may include both online synchronous and asynchronous teaching and learning experiences, structured for individual and collaborative interaction and guided by the teacher, as well as independent experiential and web-based learning, initiated and implemented by the student.

From a theoretical perspective, i^{2}Flex is a form of blended learning which so far tends to gravitate toward six models, namely face-to-face driver, rotation, flex, online laboratory, self-blend, and online driver (Hopper and Seaman 2011). Each of these models comes with its own set of characteristics, but they all fall under the following umbrella definition for blended learning in the K–12: "Blended learning is any time a student learns at least in part at a supervised brick-and-mortar location away from home and at least in part through online delivery with some element of student control over time, place, path, and/or pace" (Clayton Christensen Institute 2011, p. 5).

Where i^{2}Flex significantly diverts from blended learning and the aforementioned six models is at the component of independent inquiry and the flexibility of continuously shaping the relationship between the components of time, pace, place, and mode. According to the i²Flex, independent inquiry, albeit scaffolded and guided by faculty, is a required component of the learning experience. Another major point of this methodology refers to the outstanding learning opportunities for the development of Bloom's revised taxonomy (Anderson and Krathwohl 2001) of highest cognitive skills (analysis, evaluation, and creation) that can be created by the integration of web-based activities where the student in preparation of face-to-face class meetings can interact with the content, the technology, his/her peers, and the teacher toward advancing the less demanding cognitive skills of knowledge acquisition, comprehension, and application.

Beginning from Fall 2013, many i²Flex classes have been piloted at the ACS Athens Middle School and Academy (High School), representing a rich variety of course subjects, authentic settings, and age groups, while at the same time reflecting different degrees of complexity regarding instructional design and technology integration. ACS Athens is deeply conscious that this form of teaching and learning that faculty have been striving to implement requires substantial change in the school's culture, while at the same time generating shifts in teachers', administrators', and students' roles. As a result, the faculty currently implementing the i²Flex methodology participate in a series of individual consultations with the director for educational technology and eLearning. Their courses are being continuously reviewed according to standards developed by the Quality Matters® (2011–2013), research-based, US-developed benchmarks for online course design. In addition, the faculty examine a variety of models and discuss issues of instructional design as those which specifically apply to their courses, and how these can be transformed into a successful technology-enhanced and/or web-supported learning community.

In turn, the faculty educate hands-on their students about the uses and benefits of technology for learning, as opposed to using technology for information, communication, or entertainment per the digital natives' daily routine outside the classroom. ACS Athens administrators also have the opportunity to participate in formal and informal professional development sessions regarding the design and implementation of i²Flex**,** while receiving frequent reports on the progress of the pilot classes.

To reflect the i²Flex approach in teaching and learning, a new schedule has been implemented this school year for our middle school and the academy. The goal of this schedule is not only to allow for more quality contact time in the classroom but also for the inclusion of modules that allow self-directed learning, a vital component of meaningful and multi-dimensional learning.

Moving from the pilot to the next phase of this initiative, the vision of ACS Athens is to have all of the middle and high school courses i²Flex-ed to some degree. Indeed, the school thrives on the tremendous possibilities this new education methodology can offer to its learning community. Davis et al. (2007) illustrate among others the development of new distribution methods to enable equity and access for all students, the provision of high-quality content for all students, and the fact that management structures can begin to shift to support performance-based approaches through data-driven decision-making. Therefore, when applied in a systematic, pedagogically sound way, i²Flex can:

- Help promote and sustain the dynamic equilibrium of all TPACK elements
- Serve as the vehicle for disruptive education in the school
- Become the bridge between the four-walled, brick-and-mortar classroom and twenty-first-century education
- And, last but not least, empower ACS Athens students *to transform the world as architects of their own learning* (per the ACS newly established vision), *by linking high-quality teaching and high-quality courses with the collaborative, networked, information-rich environments that are a hallmark of the information age* (Davis et al. 2007 in Avgerinou 2013)

5 i^{2}Flex Case Studies

In this section, three i^{2}Flex case studies are briefly presented. Each of them is a manifestation of the i^{2}Flex approach in praxis in the elementary, middle, and high school (Academy). At the same time, we share an early report on benefits for both students and teachers as a result of their engagement with this innovative methodology.

5.1 Fifth Grade Architects

When the new i^{2}Flex methodology was presented to the faculty, 25 years of teaching technology was encapsulated both in it and in a project in that fifth-grade students participated.

This project encompassed the different aspects of i^{2}Flex, namely face-to-face, flexible, online, and independent learning. The students were first introduced to *Google SketchUp*. *Google SketchUp* is a 3D modeling program for architects and many other professions. To address the face-to-face learning component, the program was introduced in the computer laboratory with an initial explanation of the tools available in *Google SketchUp* and the modeling window or "canvas" that they would be using. In the next phase, students were shown a *YouTube* video with step-by-step instructions on how to make a simple house. The children were asked to open two tabs to work simultaneously with their "canvas" and with the online tutorial. This helped them to use the tools that were initially explained in the face-to-face session, to actually draw a simple house online. The final phase of using *Google SketchUp* was to draw their own building and this is where imagination, conceptualization, and finally creation occurred. This task was accomplished via independent learning.

Before embarking on this journey, students were given a little tip. They were asked to reflect on the initial online tutorial and to question whether there were more online tutorials to help with other skills needed to use *Google SketchUp*.

The teacher reports that “my students returned to class with such enthusiasm as they explained to me how they figured out ‘how to’ draw the building that they had envisioned” (Sarantes 2013, p. 14). Some students wanted to draw the interior of their building so they used an online tutorial to help them with that. Other students labeled their buildings with letters that they constructed themselves. Finally, one student said with excitement and a sense of accomplishment, “I downloaded the program and made the most beautiful house. I wanted to put furniture inside the rooms but I didn’t like the ones that were available so I drew them myself!!” (Sarantes 2013, p. 14)

5.2 i^{2}Flex and the Virtual Science Fair in the Middle School

The Near East South Asia (NESA) Virtual Science Fair (NVSF) is an international virtual project that allows middle school students to learn experientially while using the Moodle learning management system as a platform. Its goal is to expand students’ knowledge of science, and to transform their habits of mind by developing their skills to learn as scientists. Students become committed to their project idea as it is their own research-generated project and, through collaboration with their team members, their teacher-facilitator, and their e-mentors, work through the steps of the projects. Students are required to construct meaning for themselves through interaction and collaboration with others. The NVSF eventually holds a hybrid science fair with the inclusion of virtual modes and e-learning tools such as wikis and e-diaries.

The science fair is an embodiment of the i^{2}Flex paradigm and philosophy (Bakoyiannis and Rontogiannis 2013). During the science fair process, students use the Internet, acting as independent learners in a flexible collaborative environment. With their teacher and e-mentors as their guides and coaches, students take part in learning that involves creation, evaluation, and analysis: the top tiers of Bloom’s revised taxonomy (Anderson and Krathwohl 2001). Through the Moodle platform, students receive information, but also independently build on their projects creating an archive of their science research, while at the same time supporting collaboration and communication with their e-mentor. Communication via the platform is asynchronous, allowing students to work with their partners and their e-mentors in a flexible environment. Students learn to use a variety of technological resources to present and complete their projects within Moodle.

5.3 What Makes us Human?

Focusing on the essential question *what makes us human?* the Honors Humanities course encourages students to exercise their critical thinking skills as they tackle complex ideas through an interdisciplinary approach while considering such aspects from creativity, and intelligence, through our ability to directly influence and shape our future. Emphasis is placed on independent learning tasks, innovative assignments, and creative use of twenty-first-century technology. As this instructional methodology has much in common with the innovative web-facilitated i^{2}Flex design, it comes as no surprise that Honors Humanities was one of the first i^{2}Flex courses to be piloted at ACS.

A *modern classic,* the Honors Humanities program was created 40 years ago as an innovative, interdisciplinary, team-taught course that examines essential questions through literature, visual and performing arts, philosophy, and history. From the beginning, humanities field-study trips in Greece and Europe have encouraged students to become independent learners, while also developing their critical thinking skills and cultural awareness. Visiting the museums and monuments, experiencing the artifacts up close, and exploring the masterpieces studied in class, these experiences have provided students with opportunities to think, imagine, conceptualize, and create. Humanities students are guided by their teachers to develop the skills and tools to envisage the future through the study of human civilization: that is, to build the future as "Architects of their own Learning" (ACS Athens, School Vision).

From its inception, the Honors Humanities program has developed and adapted without sacrificing the four attributes which made the prototype unique. Above all, it offers a student-centered, authentic, interdisciplinary, and flexible educational experience to ACS students. These attributes have contributed to a smooth transition in the journey from the traditional face-to-face to the i^{2}Flex course. Table 20.1 shows how the integrity of the core attributes has been enhanced by the i^{2}Flex methodology.

Significant benchmarks on the instructional design and development (IDD) process toward the i^{2}Flex model were the development of two online courses with field-study components in Europe: "Classical Humanism in the Italian Renaissance" and "Classicism and Romanticism in French Art and Thought." Another milestone is the forthcoming inauguration of a newly designed online course, "Reason and Faith: Classical Humanism and Byzantine Spirituality." This course aims to bring students from Greece and abroad together, first digitally through online activities, discussion forums, and independent research, and then in person through an extensive field-study trip within Greece, where students will visit sites of cultural and historical importance.

At each stage of the IDD process, the goal has been to create and enhance courses that challenge students academically while utilizing the best existing resources and taking advantage of new technologies for learning. According to the faculty in charge of designing and teaching these courses, "The i^{2}Flex approach provides students with the flexibility, skills, and tools to tailor their future according to their needs, interests, and skills. In the new i^{2}Flex paradigm, Honors Humanities is becoming a 'modern digital classic'" (Jasonides et al. 2013, p. 22).

Returning to the earlier question as to *what makes us human,* perhaps we can assert that it is our ability to imagine the possibilities of a better future and gain knowledge and skills to adapt to the unknown. Educational methodologies like i^{2}Flex enable teachers and students at ACS Athens to do just that.

Table 20.1 The humanities course transformation from face-to-face to i²Flex

Traditional face-to-face humanities course	The i²Flex methodology
Student centered: Students find their own way into the course. Assessment is diverse to address a variety of individual learning styles and each student brings a unique approach to the field-study component	Independent investigation in flextime gives students some control over time, place, pace, and mode of learning
Authentic: The Honors Humanities course is an original ACS Athens course, which was designed specifically for our international student body	i²Flex is another authentic ACS innovation geared toward improving teaching and learning
Interdisciplinary: The team-taught and completely integrated interdisciplinary approach develops high-order critical thinking skills	The i²Flex model opens up a wider range of multimedia resources across the disciplines and develops high-order critical thinking in the online environment
Flexible: The Humanities program has not only evolved to meet the needs of twenty-first-century learners but also offers opportunities for greater personalization of the learning experiences	The i²Flex model provides a framework for continuous improvement of teaching and learning which includes an ongoing process of reflection and revision of the web-based flextime modules

6 Recommendations

Despite the fact that the i²Flex methodology is still in the pilot phase, recommendations may already be attempted with regard to (a) the process that needs to be in place, but also (b) the factors that need to be considered so that such a methodology can be successfully adopted.

6.1 Process

How can such a methodology be adopted with or without modification or customization?

According to Pelonis and Gialamas (2010), "It is easy to change policies, structures, curriculum, and management approach, but it is difficult to change how the members of the institution think and behave" (p. 76). Thus, the presence of an innovative institution leader is essential. The leader must begin with the understanding of the existing culture of the institution which is typically defined by its history, policies, management style, and, most importantly, the thinking and behavior of its constituents.

Toward that end, the following general steps are needed. The leader should:

a. Understand very well the internal (institution) and external environment (the community and the country which host the institution) in particular in relation to the infrastructure and technology capabilities of the institution and the external environment

b. Internalize, embrace, and commit to the *new approach*
c. Develop appropriate vision for the institution embracing and including the i²Flex methodology
d. Establish a leadership team by utilizing existing human resources and if necessary, recruit new personnel
e. Communicate the vision continuously to all constituencies
f. Establish clear and well-defined implementation strategies
g. Set up measurable goals and outcomes
h. Regularly assess, reflect, and modify the implementation plan
i. Evaluate the success of accomplishing the vision
j. Celebrate the success by giving generous credit (according to their contribution) to members of the leadership team and to constituencies involved

6.2 Factors

What institutional culture, human and financial resources, infrastructure (knowledge, facilities, and technology), and what type of leadership approach are necessary for such a methodology to be successfully adopted?

a. The institutional culture should be a culture embracing change and innovation; be willing to depart from the education of yesterday; and let technology enhance critical thinking, creativity, and provocative ways of addressing challenges. Besides, "education without purpose and clear vision is similar to a beautiful picture frame without a picture" (Gialamas 2014).
b. A commitment to technology, and, most important, a commitment to thinking differently must be present. In particular, technology should be viewed as being not only a tool, but also inspiration to improve the teaching and learning, as well as the leadership approach.
c. A commitment to continuously educating faculty, students, parents, and administrators to internalize the *adaptive reasoning as the thinking process of improving teaching and learning*. That means thinking logically about relationships among concepts and situations, considering alternatives, and reason, and providing justification for their conclusions.

7 Conclusion

If our goal is to successfully prepare our students for the future, we cannot continue educating them in ways that were developed for the society of the past. The world has changed exponentially in ways that are not always easy to understand so as to predict the future needs, and prepare students for them. Unfortunately, the majority of the world's education systems are still educating students in the same way as that of the nineteenth century's with at best cosmetic, yet not drastic, adaptive, conceptual, policy, and structural changes.

We should approach technology not as a convenient tool for educational, entertainment, or popular activities to the *digital omnivores* but rather as an integral part of shifting to a different level and trajectory of thinking and learning. In particular, our focus should be on how teaching and learning could be meaningful to, and transformational for, the learner and how this thinking will utilize all the benefits of *worldwide innovations* for developing critical thinking, for promoting creativity, and most important for cultivating wisdom and ethos.

In the end, academic institutions must prepare young people to navigate skillfully and confidently in the ocean of future uncertainties, always guided by ethos and the love of learning.

Acknowledgments This work would not have been accomplished without the commitment to, and enthusiasm for, the i^{2}Flex approach of ACS Athens' pioneer teachers Christina Bakoyiannis, Kathy Jasonides, Janet Karvouniaris, Labrini Rontogiannis, Helen Sarantes, and Amalia Zavacopoulou, and their students. We are deeply indebted to all of you!

References

Allen, J. E., & Seaman, J. (2013). *Changing course: Ten year of tracking online education in the United States.* Sloan Consortium, Babson Survey Research Group, & Pearson Learning Solutions. http://sloanconsortium.org/publications/survey/changing_course_2012. Accessed 11 Nov 2013.

Anderson, L. W., & Krathwohl, D. R. (Eds.). (2001). *A taxonomy for learning, teaching and assessing: A revision of Bloom's taxonomy of educational objectives*. New York: Longman.

Avgerinou, M. D. (2009). Re-viewing visual literacy in the "bain-d'-images" era. *TechTrends, 53*(2), 28–34.

Avgerinou, M. D. (2013, Winter). Digital natives, disruptive schooling and other brainteasers. *Ethos, 8*(1), 8–11.

Bakoyiannis, C., & Rontogiannis, L. (2013, Winter). NESA virtual science fair. *Ethos,* 56–58. ACS Athens Publications.

Bellanca, J., & Brandt, R. (Eds.). (2010). *21st century skills: Rethinking how students learn*. Bloomington: Solution Tree Press.

Brown, J. S., & Adler, R. P. (2008, January/February). Minds on fire: Open education, the long tail, and learning 2.0. *Educause Review*, *43*(1), 16–32. http://connect.educause.edu/Library/EDUCAUSE+Review/MindsonFireOpenEducationt/45823?time=1206929786. Accessed 10 Feb 2008.

Business-Higher Education Forum. (2005). *A commitment to America's future: Responding to the crisis in mathematics & science education*. Washington D.C.: Business-Higher Education Forum.

Christensen, C. M., Horn, M. B., & Johnson, C.W. (2011). *Disrupting class: How disruptive innovation will change the way the world learns*. New York: McGraw-Hill.

Clayton Christensen Institute. (2011). *The rise of K-12 blended learning: Profiles of emerging models*. http://www.christenseninstitute.org/?publications=the-rise-of-k-12-blended-learning-profiles-of-emerging-models. Accessed 11 Nov 2013.

Corrin, L., Bennett, S., & Lockyer, L. (2011). The life of a 'digital native'. In T. Bastiaens & M. Ebner (Eds.), *Proceedings of ED-MEDIA 2011: World conference on educational multimedia, hypermedia and telecommunications* (pp. 2942–2951). Chesapeake: AACE.

Darling-Hammond, L. (2010). New policies for 21st century demands. In J. Bellanca & R. Brandt (Eds.), *21st century skills: Rethinking how students learn* (pp. 33–49). Bloomington: Solution Tree Press.

Davis, N. E., & Niederhauser, D. S. (2007, April). New roles and responsibilities for distance education in K-12 education. *Learning and Leading with Technology, 34*(7), *10–15*.

Davis, N., Roblyer, M. D., Charania, A., Ferdig, R., Harms, C., Compton, L. K. L., et al. (2007). Illustrating the "virtual" in virtual schooling: Challenges and strategies for creating real tools to prepare virtual teachers. *Internet and Higher Education, 10*(1), 27–39.

Dede, C. (2005). Planning for neomillennial learning styles. *EDUCAUSE Quarterly, 28*(1), 7–12.

Dede, C. (2010). Comparing frameworks for 21st century skills. In J. Bellanca & R. Brandt (Eds.) *21st century skills: Rethinking how students learn* (pp. 51–75). Bloomington: Solution Tree Press.

Fogarty, R., & Pete, B. M. (2010). The Singapore vision: Teach less, learn more. In J. Bellanca & R. Brandt (Eds.), *21st century skills: Rethinking how students learn* (pp. 97–116). Bloomington: Solution Tree Press.

Gardner, H. (2010). Five minds for the future. In J. Bellanca & R. Brandt (Eds.), *21st century skills: Rethinking how students learn* (pp. 9–31). Bloomington: Solution Tree Press.

Gialamas, S. (2011, October 30). Leadhership collaboration: High school and college environments. International Herald Tribune. Accessed April 10, 2014 from http://www.acs.gr/storage/gialamas/IHT-Oct-13-2011.pdf

Gialamas, S. (2014, January 15). Educating for Change. *Panel Discussion.* ACS Athens.

Gialamas, S., & Pelonis, P. (2009). Morphosis leadership being visionaries in a changing world. *Academic Leadership Online*, *7*(2). http://www.academicleadership.org/327/morphosis-leadershipbeing-visionaries-in-a-changing-world/.

Hopper, J., & Seaman, J. (2011). *Transforming schools for the 21st century*. http://www.designshare.com/index.php/articles/transforming-schools-for-the-21st-century/. Accessed 6 Nov 2003.

Jakes, D., & Brennan, J. (2006). *Visual literacy and the 21st Century skills*. http://www.techlearning.com/techlearning/events/techforum06/DavidJakes & JoeBrennan_ProgramGuide.pdf. Accessed 28 Jan 2008.

Jasonides, K., Karvouniaris, J., & Zavacopoulou, A. (2013, Winter). What makes us human? *Ethos*, 20–22. ACS Athens Publications.

Jenkins, H. (2007). *Confronting the challenges of participatory culture: Media education for the 21st century*. http://www.molotech.org.za/blog/2007/06/12/need-for-21st-century-skills/. Accessed 2 Feb 2008.

Jones-Kavalier, B. R., & Flannigan, S. L. (2008). Connecting the digital dots: Literacy of the 21st century. *Literacy of the 21st Century*, *35*(3), 13–16.

Kay, K. (2010). Foreword: 21st century skills: Why they matter, what they are, and how we get there. In J. Bellanca & R. Brandt (Eds.), *21st century skills: Rethinking how students learn* (pp. xiii-xxxi). Bloomington: Solution Tree Press.

Koehler, M. J., & Mishra, P. (2008). Introducing TPCK. In AACTE committee on innovation and technology (Ed.), *The handbook of technological pedagogical content knowledge (TPCK) for educators* (pp. 3–29). New York: American Association of Colleges of Teacher Education and Routledge.

Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A new framework for teacher knowledge. *Teachers College Record, 108*(6), 1017–1054.

Mitra, S. (2005). Self organising systems for mass computer literacy: Findings from the 'hole in the wall' experiments. *International Journal of Development Issues, 4*(1), 71–81.

National Leadership Council for Liberal Education and America's Promise. (2007). *College learning for the new global century*. Washington D.C.: Association of American Colleges and Universities.

Newcastle University-Press Office. (2013). *Sugata's first school in the cloud opens*. http://www.ncl.ac.uk/press.office/press.release/item/sugata-s-first-school-in-the-cloud-opens-its-doors. Accessed 22 Dec 2013.

North Central Regional Educational Laboratory & the Metiri Group. (2003). *enGauge 21st century skills: Literacy in the digital age*. Chicago: North Central Regional Educational Laboratory.

Oblinger, D. G., & Oblinger, J. L. (Eds.). (2005). *Educating the net generation*. Educause. https://net.educause.edu/ir/library/pdf/pub7101.pdf. Accessed 16 Jan 2014.
Organization for Economic Co-operation and Development. (2005). *The definition and selection of key competencies: Executive summary*. Paris: Author.
Partnership for 21st Century Skills. (2006, July). *A state leaders action guide to 21st century skills: A new vision for education*. Tuscon: Author.
Partnership for 21st Century Skills. (2009). *Framework for 21st century learning*. http://www.p21.org/about-us/p21-framework. Accessed 7 Nov 2013.
Pearlman, B. (2010). Designing new learning environments to support 21st century skills. In J. Bellanca & R. Brandt (Eds.), *21st century skills: Rethinking how students learn* (pp. 117–147). Bloomington: Solution Tree Press.
Pelonis, P., & Gialamas, S. (2010). An international perspective of academic leadership. *International Schools Journal, XXX*(1), 72–85.
Pink, D. H. (2006). *A whole new mind: Why right-brainers will rule the future*. New York: Penguin.
Prensky, M. (2001). *Digital natives; digital immigrants*. http://www.marcprensky.com/writing/Prensky%20-%20Digital%20Natives,%20Digital%20Immigrants%20-%20Part1.pdf. Accessed 11 Nov 2013.
Quality Matters® Rubric. (2011–2013). Maryland online.
Rice, J.K. (2012). *Review of "the costs of online learning."* Boulder: National Education Policy Center. http://nepc.colorado.edu/thinktank/review-cost-of-online/. Accessed 1 June 2013.
Robinson, K. (2001). *Out of our minds: Learning to be creative*. Westford: Capstone Publishing Ltd.
Sarantes, H. (2013, Winter). Fifth grade architects. *Ethos,* 14.
Shulman, L.S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*(2), 4–31.
Shulman, L. S. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review, 57*(1), 1–22.
Watson, J., Murin, A., Vashaw, L., Gemin, B., & Rapp, C. (2010). *Keeping pace with K-12 online learning: An annual review of state-level policy and practice*. Vienna: North American Council for Online Learning. http://www.kpk12.com/wp-content/uploads/KeepingPaceK12_2010.pdf. Accessed 14 Dec 2013.

Index

Symbols
21st century skills, 109, 167, 329, 335

A
Assessment, 44, 71, 76, 81, 83–86, 89, 90, 93, 150, 198, 297
  and grading, 204
  evaluation methods of, 35
  formative, 97
  frameworks for, 35
  methods, 81
  MOOCs in, 35
  of learning process, 49, 50
  of scientific knowledge, 294
  of student's grade, 73
  teaching, 70
  test, 228
  types of, 93
  using NBAS, 71
Attitudes, 164, 168, 196, 198–200, 203, 207, 209, 307, 309
Augmented reality (AR), 294, 297–299, 302

B
Big ideas of science, 236, 241, 243, 246, 254

C
Cognitive engagement, 101, 102, 109, 110, 113
Cognitive learning, 84
Collaboration, 36, 47, 141, 142, 150, 164, 168, 171, 174, 198, 200, 207, 258, 262, 264, 266, 269–271, 277, 281, 286, 297, 298, 301, 302, 338
  amongst M-learners, 123
  environments, 42
  frameworks of, 166
  skills, 277
Collaborative learning, 30, 41, 50, 51, 152, 155, 164, 174, 177
Collaborative simulator games, 213
Community memory, 258, 271, 272
Community of learners, 133, 335
Computer Supported Collaborative Learning (CSCL), 108
Conceptual learning, 161, 295
Creative, 84, 97, 98, 175, 257, 262, 268–270
  communities, 262, 269, 271
Creative communities, 268
Critical thinking, 107, 109, 139, 142, 156, 197, 200, 294, 338, 342
Crowd sourcing, 121, 124
Curriculum mapping, 70, 73, 76

D
Digital, 3, 13, 44, 45, 59, 84, 92, 98, 104, 182, 183, 286
  games, 181, 182, 184, 189, 196, 198, 199, 201, 203, 207, 208, 210, 289
Digital learning games (DLGs), 181, 183, 187, 191
Disruptive education, 337

E
Educational visualizations, 258, 259, 262, 267
Education paradigm, 333
eMaturity, 308, 313, 315, 316, 317, 319
Emotion, 181, 185, 187, 333
Evaluation
  framework, 196, 201, 204, 206, 207, 210, 313
  indicators, 200, 201, 206, 210
Exhibit design, 65, 295

D. G. Sampson et al. (eds.), *Digital Systems for Open Access to Formal and Informal Learning,*
DOI 10.1007/978-3-319-02264-2,

F
Federated infrastructure, 12, 15, 20, 61
Flipped class, 30, 32
Formal and informal learning, 2, 110, 122, 124, 190

G
Game, 48, 49, 51, 133, 184, 189, 190, 196
advocates of, 182
boundaries of, 43
environment of, 43
online, 42
Game based learning (GBL), 181
Graduate attribute, 69, 70, 81

H
Higher education, 25, 28, 30, 31, 51, 82, 85, 153, 154, 156, 213, 214, 224, 333, 335

I
i2Flex, 335–339
ICT uptake, 308, 313, 317
Inclusive learning, 57, 58, 60, 62, 64, 66, 67
Innovative leadership, 334
Inquiry, 102, 108, 111, 112, 160, 161, 169, 199
independent, 336
scientific, 103, 177, 296, 298
Inquiry-based science learning (IBSE), 101, 105, 112, 160

K
K-12 blended learning, 335

L
Lab
metadata, 236, 240, 246
repositories, 236, 254
Learning
empowerment, 242
outcome, 26, 45, 48, 50, 70–77, 79, 81, 82, 90, 93, 108, 164, 199, 210, 295, 302
Learning object (LOs), 11, 17, 58, 104, 267
Learning to learning together (L2L2), 159, 160, 163, 165, 168, 169, 175–177
Location-based
mobile learning, 139, 141
system, 143

M
Massively Multiplayer Online Games (MMOGs), 41
Massive open online course (MOOCs), 26, 32–35, 37, 41–43, 45–51, 84, 98, 108, 121, 124
Mobile language learning, 124
application, 122
Mobile learning, 123, 124, 139, 141, 153
Morfosis, 333–335
Motivation, 32, 45, 51, 87, 95, 101, 127, 133, 152, 160, 165, 181, 182, 187, 198, 200, 207, 275, 276, 284, 294, 298
and determination, 45
and engagement, 42, 44, 46, 51
techniques, 49
Multimedia, 93, 94, 96, 97, 125, 142, 298

O
Online
assessments, 87
communities, 187
courses, 25, 28
educational portal, 11
learning, 42, 44, 47, 48, 51
learning environment, 41, 164
tutorial, 337
Open access, 2–4, 32, 61, 112, 122–124, 135, 190–192
concerns of, 190
to static educational resources, 41, 43
Open educational resources (OERs), 11, 26, 27, 29, 109
Organizational competence, 308–310, 313, 316–319, 322

P
Pedagogical design, 42–44
People with disabilities, 58, 59, 61, 67
Portal, 12, 13, 29, 59, 61

R
Reflection, 109, 111–113, 142, 174, 175, 207, 297
tool, 160, 167, 177
Reliability, 83, 88–90, 94, 98, 204, 283
Remote labs, 235–237, 241, 242, 246, 254
Repository, 3, 16, 59, 63, 124, 127, 130, 131, 259
Go-Lab project, 254
LingoBee, 126–128, 134, 135
networks, 21, 66
of virtual places, 258
shared, 259
Requirements analysis, 12, 59

S
Scaffolding, 101, 135, 142, 207, 294, 298, 300
School competence profile, 317, 323
School entrepreneurship education, 196–199, 207, 208, 210

Science museum, 293–295, 298, 300
Science, Technology engineering and mathematics (STEM), 4, 213
Secondary education, 197
Second life, 33, 258, 260, 262, 266, 269, 270
Skills
  domain-specific, 69, 70, 72, 77
  language-learning, 77
  problem-solving, 48, 49
Social
  creativity, 257, 269, 271, 282
  media, 43, 106, 107, 109, 121, 122, 124, 133, 135, 257, 272
  networking, 41, 122, 124, 126, 127, 133–136, 160

T
Technology Enhanced Learning (TEL), 58, 121, 122, 133
Theory, 105
  educational theory, 108
  learning, 30, 43, 181
  motivation theory, 186
  oriented approach, 204
  planned behaviour theory, 200
  self-determination theory, 45, 186
  Siemens' theory, 107
Tool, 4, 13, 26, 27, 43
  aligned, 19
  assessment, 92
  authoring, 19, 62
  collaboration, 65
  communication, 47, 51
  social, 32
  tutoring, 215, 219, 222

U
University open course, 2, 25
User interface, 277, 282, 283
  tools, 58

V
Video, 32–34, 45, 92, 93, 95, 96, 126
  clip, 29–31, 34, 35
  lectures, 30
  on YouTube, 30, 337
  streaming, 26
Virtual labs, 235–237
Visualization, 72, 258, 259, 262, 266, 267, 269, 271, 298, 302

W
Web accessibility, 61
Why-dimension, 101, 109, 112, 113
Why-questioning, 101, 108–113