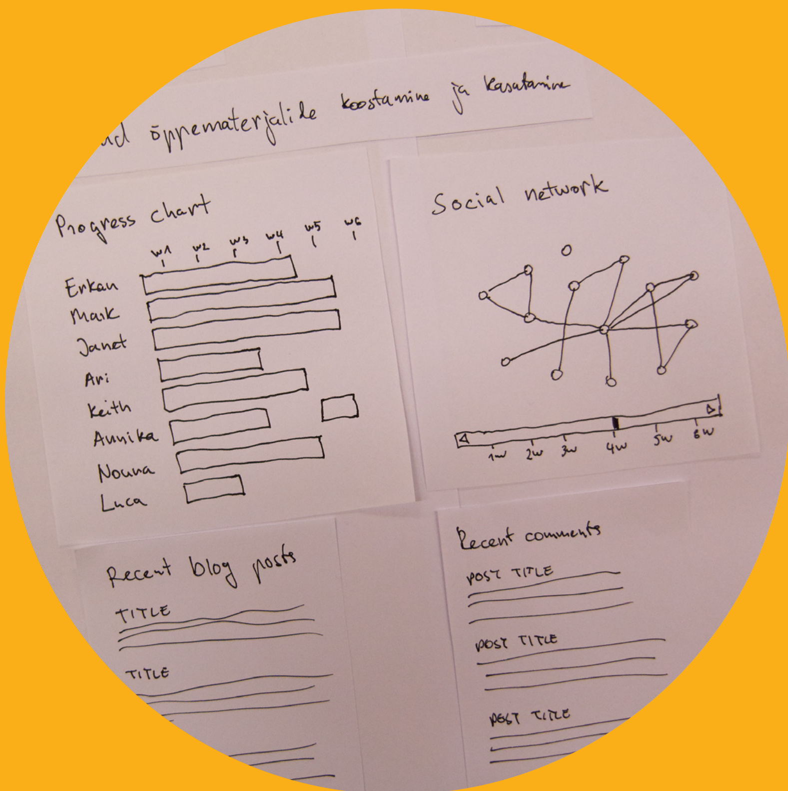
Department of Media

The Structure and Components for the Open Education Ecosystem

Constructive Design Research of Online Learning Tools

Hans Põldoja



Aalto University
DOCTORAL DISSERTATIONS

Aalto University publication series
DOCTORAL DISSERTATIONS 175/2016

The Structure and Components for the Open Education Ecosystem

Constructive Design Research of Online Learning Tools

Hans Põldoja

Aalto University
School of Arts, Design and Architecture
Department of Media
Learning Environments Research Group

Main dissertation advisor
Professor Teemu Leinonen, Aalto University, Finland

Co-dissertation advisors
Professor Erik Duval, Katholieke Universiteit Leuven, Belgium
Paul Kahn, Mad*Pow, United States

Opponent
Professor Emeritus Terry Anderson, Athabasca University, Canada

Aalto University publication series
DOCTORAL DISSERTATIONS 175/2016

ISBN 978-952-60-6994-4 (printed)
ISBN 978-952-60-6993-7 (pdf)
ISSN-L 1799-4934
ISSN 1799-4934 (printed)
ISSN 1799-4942 (pdf)
http://urn.fi/URN:ISBN:978-952-60-6993-7

Unigrafia Oy
Helsinki 2016

Finland

NORDIC ECOLABEL
441 697
Printed matter

A! Aalto University

Abstract

Aalto University, P.O. Box 11000, FI-00076 Aalto www.aalto.fi

Author
Hans Põldoja

Name of the doctoral dissertation
The Structure and Components for the Open Education Ecosystem

Publisher School of Arts, Design and Architecture

Unit Department of Media

Series Aalto University publication series DOCTORAL DISSERTATIONS 175/2016

Field of research New Media

Date of the defence 23 September 2016

Language English

☐ **Monograph** ☒ **Article dissertation** ☐ **Essay dissertation**

Abstract

This research studies the design of online learning tools for open education. The dissertation is based on five articles and design case studies that explore open education from different perspectives: open educational resources, open learning environments, and assessment of teachers' competencies. The underlying concept of the study is the open education ecosystem. The study explores the ways in which the design of online learning tools could benefit from the digital ecosystems approach. The design of online learning tools for open education presents wicked problems, that involve ill-defined requirements and contemplates the influence on and by the stakeholders and other components of the ecosystem. Firstly, to clarify the design challenges related to the open education ecosystem, this study summarizes a set of design challenges presented in design case studies. Secondly, it identifies and recommends a set of design patterns that address these design challenges. Finally, the study proposes the structure and components that are needed for the open education ecosystem.

Keywords open education, digital ecosystems, design patterns

ISBN (printed) 978-952-60-6994-4	**ISBN (pdf)** 978-952-60-6993-7	
ISSN-L 1799-4934	**ISSN (printed)** 1799-4934	**ISSN (pdf)** 1799-4942
Location of publisher Helsinki	**Location of printing** Helsinki	**Year** 2016
Pages 208	**urn** http://urn.fi/URN:ISBN:978-952-60-6993-7	

Acknowledgements

It is almost 13 years since I started my doctoral studies. A lot of people have helped me during this long way. First of all, I want to thank my supervisor Teemu Leinonen for inviting me to do my doctoral studies in Helsinki. Media Lab Helsinki was a great place to learn about design. Learning Environments group was more like a band than a traditional research group. In this environment, I found doing actual design work more engaging than writing a dissertation. Teemu never lost belief in me and helped me to get back on track with writing. His methodological guidance and detailed comments on the manuscript helped me to finalize the dissertation.

My thesis advisors Erik Duval and Paul Kahn have supported me in various phases of this work. Erik encouraged me to aim higher instead of going for quick wins. I would not have successfully completed my final publication without his encouragement and guidance. Sadly, he passed away in March 2016. Me and Teemu both learned a lot from him. Paul looked at my work from a different perspective and ensured that it is also relevant outside the technology-enhanced learning community.

I want to thank my pre-examiners Vladan Devedzic and Lisa Petrides for taking their time to review my work. Their feedback has helped me to refine the dissertation. I am also honored that Terry Anderson has accepted to act as opponent in my defense.

During my time in Helsinki I had a pleasure to work together with a number of talented doctoral students. We did several course projects together with Mariana Salgado. Andrea Botero has helped me with many things. Joanna Saad-Sulonen gave detailed feedback on the early version of my manuscript. With Nuno Correia we shared a common interest in music. Our doctoral program had a lot of freedom and flexibility. Lily Diaz and Mauri Kaipainen helped us with keeping our studies on track.

After my studies in Helsinki, I returned to the Centre for Educational Technology in Tallinn University. Here I have done several design projects and research publications together with Mart Laanpere, Terje Väljataga and Kairit Tammets. Terje and Kairit have inspired me not to give up my doctoral studies. I have also got help and feedback from Kai Pata and Tobias Ley.

Riina Vuorikari and Sebastian Fiedler have been good friends and research partners. It is always great to meet them and to discuss about learning, design, openness, and other topics.

Design ideas do not turn into software prototypes without developers. I have been lucky to work together with Pjotr Savitski, Jukka Purma, Tarmo Toikkanen, Meelis Mets, Vahur Rebas, and Aili Madisson. Priit Tammets has helped me with graphical design.

Antti Ellonen and Marjo Priha provided input for the PILOT project and my first publication in this dissertation. David Maxwell did language editing for my final publication and the dissertation. Sanna Tyyri-Pohjonen assisted me with questions related to publishing the dissertation.

My doctoral studies in Finland became possible with the support from the Kristjan Jaak Scholarship programme by the Archimedes Foundation. School of Digital Technologies in Tallinn University has supported my studies in various ways and provided me with flexible working conditions that allowed me to finalize my dissertation.

Writing a doctoral dissertation and life in general is not always fun. My good friends Tiina, Keit and Pirje have made me laugh and supported me during difficult moments.

Finally, I would like to thank my parents for their patience and support.

Thank You! Kiitos! Suur tänu!

Tallinn, August 2016
Hans Põldoja

Contents

Acknowledgements........1
List of Abbreviations........7
List of Publications........9
Author's Contribution........11
1. Introduction........13
1.1 The Research Context........13
1.2 Defining the Problem Area........16
1.3 Aims of the Study........17
1.4 Design Cases........17
1.5 Research Questions........18
1.6 The Structure of the Dissertation........18
2. Theoretical Framework and Key Concepts........19
2.1 Historical Perspective: Five Generations of Computers in Education 19
2.1.1 Computer Assisted Instruction........20
2.1.2 Computer-Based Training........21
2.1.3 Web-Based Training........22
2.1.4 E-learning........22
2.1.5 Technology-Enhanced Learning........23
2.2 Open Education........24
2.2.1 The Historical and Philosophical Background of Open Education 24
2.2.2 Open Educational Resources........27
2.2.3 Open and Personal Learning Environments........29
2.2.4 Open Online Courses........30
2.2.5 Assessment and Recognition of Open Learning........33
2.3 Open Education as an Ecosystem........34
2.3.1 Digital Ecosystems........34
2.3.2 Digital Learning Ecosystems........38

2.3.3 Ecosystem Perspectives on Open Education 41
2.4 Design in Context 43
2.4.1 Design Approach 43
2.4.2 Pattern Languages in Design 45
2.5 Summary 47
3. Methodological Considerations 49
3.1 Design Practice and Design Exploration of Online Learning Tools 52
3.2 Design Studies on Challenges, Patterns and Structure of the Open Education Ecosystem 53
4. Original Publications 55
4.1 Publication 1: Progressive Inquiry Learning Object Templates (PILOT) 55
4.2 Publication 2: Information Architecture and Design Solutions Scaffolding Authoring of Open Educational Resources 56
4.3 Publication 3: Design and Evaluation of an Online Tool for Open Learning with Blogs 57
4.4 Publication 4: Externalization of a PLE: Conceptual Design of LeContract 58
4.5 Publication 5: Web-based self- and peer-assessment of teachers' digital competencies 59
5. Tools Designed 61
5.1 PILOT 62
5.2 LeMill 64
5.3 EduFeedr 66
5.4 LeContract 68
5.5 DigiMina 69
6. Results 73
6.1 Design Challenges for the Open Education Ecosystem 73
6.1.1 Challenges for Open Educational Resources 73
6.1.2 Challenges for Blog-based Open Online Courses 76
6.1.3 Challenges for Assessment and Recognition of Competencies 78
6.1.4 Summarizing the Design Challenges 79
6.2 Design Patterns for the Open Education Ecosystem 79
6.2.1 Collaborative Authoring of Open Educational Resources 80
6.2.2 Blog-based Open Online Courses 89
6.3 The Structure and Components of the Open Education Ecosystem 98
6.4 Summary 104

7. Discussion 105
7.1 Theoretical Implications 105
7.2 Practical Implications 106
7.3 (In)validity and (Un)reliability 107
7.4 Limitations of the Study 108
7.5 Recommendations for Further Research 108
References 111
Publication 1 125
Publication 2 137
Publication 3 153
Publication 4 173
Publication 5 187

List of Abbreviations

API	Application Programming Interface
CAI	Computer-Assisted Instruction
CC	Creative Commons
DLE	Digital Learning Ecosystem
ELES	E-learning Ecosystem
HTML	HyperText Markup Language
HTTP	Hypertext Transfer Protocol
ISTE	International Society for Technology in Education
LMS	Learning Management System
MOOC	Massive Open Online Course
NETS-T	National Educational Technology Standards for Teachers
OB	Open Badge
OECD	Organisation for Economic Co-operation and Development
OEE	Open Education Ecosystem
OEF	Open Education Framework
OER	Open Educational Resources
OPML	Outline Processor Markup Language
PILOT	Progressive Inquiry Learning Object Template
PLE	Personal Learning Environment
RSS	Rich Site Summary
SOA	Service-Oriented Architecture
TEL	Technology-Enhanced Learning
UNESCO	United Nations Educational, Scientific and Cultural Organization
URI	Uniform Resource Identifier

VLE	Virtual Learning Environment
WWW	World Wide Web

List of Publications

This dissertation is based on the following five publications that are referred to in the text as Publications 1 through 5:

1. Põldoja, H., Leinonen, T., Väljataga, T., Ellonen, A., & Priha, M. (2006). Progressive Inquiry Learning Object Templates (PILOT). *International Journal on E-Learning, 5*(1), 103–111.

2. Leinonen, T., Purma, J., Põldoja, H., & Toikkanen, T. (2010). Information Architecture and Design Solutions Scaffolding Authoring of Open Educational Resources. *IEEE Transactions on Learning Technologies, 3*(2), 116–128. http://doi.org/10.1109/TLT.2010.2

3. Põldoja, H., Duval, E., & Leinonen, T. (2016). Design and evaluation of an online tool for open learning with blogs. *Australasian Journal of Educational Technology, 32*(2), 64–81. http://dx.doi.org/10.14742/ajet.2450

4. Põldoja, H., & Väljataga, T. (2010). Externalization of a PLE: Conceptual Design of LeContract. In *The PLE 2010 Conference Proceedings*. Barcelona: Citilab. Retrieved from http://pleconference.citilab.eu/cas/wp-content/uploads/2010/06/ple2010_submission_68.pdf

5. Põldoja, H., Väljataga, T., Laanpere, M., & Tammets, K. (2014). Web-based self- and peer-assessment of teachers' digital competencies. *World Wide Web, 17*(2), 255–269. http://doi.org/10.1007/s11280-012-0176-2

Author's Contribution

Publication 1: Progressive Inquiry Learning Object Templates (PILOT)

The author was responsible for describing the design and development of PILOT's. Teemu Leinonen assisted with structuring the publication and formulating the research problems. Sections relating to the pedagogical foundations and research problems were written together.

Publication 2: Information Architecture and Design Solutions Scaffolding Authoring of Open Educational Resources

The author contributed mostly to the sections that described the design process and the implementation of design solutions in the LeMill software. The author also wrote the section related to the licensing of OER's, created the concept map of LeMill and made minor edits to other sections.

Publication 3: Design and evaluation of an online tool for open learning with blogs

The author was the main author of the publication. Co-authors assisted with formulating the research questions, planning the evaluation study and discussing the results of the evaluation.

Publication 4: Externalization of a PLE: Conceptual Design of LeContract

The author was responsible for structuring the publication, reporting the design process and presenting the conceptual design of LeContract.

Publication 5: Web-based self- and peer-assessment of teachers' digital competencies

The author wrote the sections on the design methodology, conceptual design, and software implementation of DigiMina. The author also contributed to the introduction, conclusions, and the validation study.

1. Introduction

Over the past 20 years we have witnessed how the use of the Web has made possible new educational practices, including both *open* and *personal* practices. These changes have taken place both at the institutional level and at the level of individual learners and educators. This dissertation investigates the design of online learning tools that enable teachers and learners to focus their practices on *openness*.

The first chapter introduces the research context, delimits the problem area, outlines the aims of the study, and establishes the research questions. This chapter also provides a short description of five design cases on which this study is built on and introduces the structure of the dissertation.

1.1 The Research Context

Online learning tools are described as tools that have been specifically designed for learning and are connected over a computer network, typically over the Internet. *Open education* refers to free and open access to education. Together with open source software, open access, and open content it belongs to a larger family of open movements that gained attention in the early 1960s. My dissertation studies five design projects of online services and learning tools that approach open education from different angles. This interdisciplinary study combines theories, methods and practices from four different areas: technology-enhanced learning, open education, digital ecosystems and design. Through technology-enhanced learning and open education it is also connected to educational science.

The first large scale initiatives of using computers in education date back to 1960s (Molnar, 1997). Over the years a number of terms such as computer-assisted instruction, computer-based education, computer-aided learning, educational technology, online learning, networked learning, and e-learning have been used when talking about the use of computers in learning and teaching. This dissertation uses technology-enhanced learning (TEL) as an umbrella term to refer to the support of any learning activity through technology. The term *technology-enhanced learning* came into use in late 1990s. Therefore it typically refers to the use of *digital technology* in learning (Chan et al., 2006). Conole, Scanlon, Mundin, and Farrow (2010) emphasize that TEL is a complex and highly interdisciplinary field that brings together researchers from social sciences (education, psychology), technology (computer science, information science) and design, as well as subject-matter experts. TEL research has a number of sub-areas that include computer-supported collaborative learning, improving practices of formal education, informal learning, interoperability of technological learning services, personalization of learning and others (Wild, Lefrere, Scott, & Naeve, 2013). TEL tools include both hardware (e.g. interactive whiteboards, handheld technologies) and software. Common types of TEL software are online learning services, virtual learning environments (VLE), authoring and delivery tools for learning content, collaboration tools, assessment tools, e-portfolios and others. My focus is on the design of web-based TEL software for open education. My special interest is in supporting open and personal approaches to learning.

Introducing technology to education is a complex process. Technological innovations must go hand in hand with social innovations. One of the social innovations that have impacted education in the last dozen years is the *open education* movement. Openness in education has multiple dimensions and therefore there is no one definition of open education. According to Iiyoshi and Kumar (2008, p. 2) the key assumption behind open education is that "education can be improved by making educational assets visible and accessible and by harnessing the collective wisdom of a community of practice and reflection". Most commonly open education is associated with *open educational resources* (OER). In a basic sense, OER can be understood as teaching, learning and research materials that can be freely accessed, used, adapted and redistributed. In recent years other aspects of openness such as open online courses (Rodriguez, 2013) and open badges (Jovanovic & Devedzic, 2015) have gained attention. Open education can be connected to a number of earlier open movements, such as the public library movement, free adult education, open universities, open classroom movement, and free software movement. When discussing open education, it is important to understand the subtle distinction between *free* and *open*. In the educational context, free refers to access without any cost. Open typically refers to the licensing model that grants users with more permissions than offered by the standard copyright law, but it may also refer to the openness of environment or processes.

Both technology-enhanced learning and open education are related to educational science. The era of information technology and the Web has inspired and facilitated a broader discussion about learning theories. For instance, Paavola, Lipponen, and Hakkarainen (2004) have proposed that there are three main metaphors to describe the genesis of new knowledge — *acquisition*, *participation*, and *knowledge-creation*. The acquisition approach, understanding the mind as a kind of container that can be filled with new knowledge, has been historically the most prominent one. The participation view sees learning as a process of participation in various cultural practices and shared activities. Design cases presented in this dissertation follow the knowledge-creation approach that emphasizes the importance of collective knowledge creation through developing shared objects of activity. This approach is in line with the basic principles of open education because it puts learners in the active role of creators and encourages sharing. There are a number of pedagogical models that can be associated with the knowledge-creation approach. From these, the *progressive inquiry* (Muukkonen, Hakkarainen, & Lakkala, 2004) pedagogical model is most closely related to my work. In the open education field there is a trend of making learning more personal by using personal technologies and giving more control to the learner. In the TEL field, this approach is known as the *personal learning environment* (PLE) (Attwell, 2007). Both open educational resources and personal learning environments are associated with blurring the borders between formal and informal learning (Hylén, 2008; Peña-López, 2013).

The rise of Web 2.0 (O'Reilly, 2005) and personal mobile technologies has changed traditional software design paradigms. Instead of complex and feature-rich monolithic software systems we see lightweight web and mobile applications that are focused on a few key features. Each user can compile a preferred set of tools from a large number of available applications. This means that different applications must be able to communicate and exchange data between each other. Often an ecosystem metaphor is used when talking about this kind of complex digital systems. Several authors have pointed out that considering the similarities between natural and digital systems we could use the term *digital ecosystems* (Briscoe & De Wilde, 2006; Chang & West, 2006). Briscoe and De Wilde (2009) define digital ecosystems as "distributed adaptive open socio-technical systems, with properties of self-organisation, scalability and sustainability, inspired by natural ecosystems". The emerging interest towards digital ecosystems has lead to the discussions that technology-enhanced learning could benefit from digital ecosystems approach (Uden, Wangsa, & Damiani, 2007; Gütl & Chang, 2008). Also, the open education community, both researchers and practitioners have started discussing about open education as an ecosystem. One of the first attempts to map the open education as an ecosystem took place at iCommons Summit 2007 (Schmidt & Surman, 2007). Brown and Adler (2008) are writing about the emergence of open participatory learning ecosystems. A number of authors are discussing about *OER ecosystem* (Mackintosh, 2012; McAndrew & Farrow, 2013; Yuan, Robertson, Campbell, & Pegler, 2010). However, often the word *ecosystem* is used just as a metaphor without connecting it to the digital ecosystems studies. This dissertation approaches the design of online learning tools for open education from the perspective of the digital ecosystems. Online learning tools designed in this study cover different aspects of open education and can be combined in multiple ways with other learning tools. Design decisions have been influenced by other components of the ecosystem such as existing software tools and various regulations (technical specifications, intellectual property licensing schemes, etc).

Methodologically, this dissertation belongs to the field of design research. In its broadest sense, design can be described as planning and giving form to new products. Traditionally, *design* has been a field of practice, but in recent decades a school of *design research* has emerged. In design research, challenges are addressed through practice. When design researchers actually construct something, they will inevitably discover problems and details that would otherwise remain unnoticed. My dissertation can be categorized as constructive design research (Koskinen, Zimmerman, Binder, Redström, & Wensveen, 2011) in which concepts, scenarios, mockups and actual software prototypes are constructed. In software design this dissertation focuses on interaction design. It is a design field that deals with defining the structure and behavior of interactive systems. This study follows the participatory design approaches (Ehn, 1992) to involve users as co-designers in the design process. Engaging users and other stakeholders in the design process raises a need for common language that is equally understood by all partners. For this purpose, scenarios (Carroll, 2000) and design patterns (Alexander, 1979) are developed in this study.

The key concept of my dissertation is the *open education ecosystem (*OEE*)*. Although this concept has been used by other scholars (Lesko, 2013; Mackintosh, 2012; Schmidt, Geith, Håklev, & Thierstein, 2009), there is no established definition. Related concepts will be discussed and a definition will be proposed in Section 2.3.3 in the theoretical framework of this dissertation. The focus of this study lies at the intersection of technology-enhanced learning, open education and digital ecosystems. Design has provided the methodology and practices for this study.

1.2 Defining the Problem Area

The constantly changing socio-technical environment sets new challenges for designing online learning services and tools. Openness, the use of social media, and personalization of learning experiences are among the recent trends in school and higher education. Learners and teachers find creative ways to use a large variety of online tools for learning purposes, although many of these tools have not been specifically designed for education. Many of these Web 2.0 tools are under constant development. This raises new kinds of technical issues such as coordinating and following the learning activities, exchanging data between the tools, archiving the outcomes, etc. Diversity and evolvement of technology are just some of the variables in the open education ecosystem. Openness introduces several new issues such as copyright licensing, business models, privacy and control. The changes also require new pedagogical approaches. For example, a recent challenges for education are the so-called Massive Open Online Courses (MOOCs) that can have thousands of participants.

It is clear that online learning tools for such an evolving and self-organizing ecosystem cannot be completely predesigned. Design problems are often *wicked problems* that have no definitive formulation (Rittel & Webber, 1973). Wicked problems have incomplete, contradictory, and changing requirements that are difficult to identify beforehand. In that sense designing learning services and tools for open education is a wicked problem. Online learning tools have to be designed open and flexible enough, so that users could repurpose and combine them with other tools during the use. Learning tools built for open education have a certain effect also on the whole open education ecosystem. It is a challenge to build tools that respect the ecosystem and its inhabitants, not break its internal relationships.

Based on the discussion above, a major problem area in this study is that designing online learning tools for the open education ecosystem involves uncertain requirements and has to contemplate the influences on and by the stakeholders and other components of the ecosystem.

1.3 Aims of the Study

This study has two main aims. The first aim is to develop new knowledge concerning the potentially needed structure and components of the open education ecosystem. The majority of the authors who have used the "open education ecosystem" concept have stayed on the metaphorical and theoretical level. Exhaustive studies concerning open educational resources have been carried out (Atkins, Brown, & Hammond, 2007; Geser, 2007; OECD, 2007; Tuomi, 2006), but these focus only on the learning content aspect of the ecosystem. A better understanding about open education as a digital ecosystem would benefit educators, researchers, designers, policy makers, and other stakeholders in the field of open education.

The second aim of this study is to provide research-based insights into designing online learning services and tools for open education. To achieve this aim it is important to map the various technical, pedagogical and social design challenges related to the open education ecosystem. These design challenges are studied through five design projects that focus on different aspects of open education. Together with the design challenges this study aims to provide a number of recommended design patterns for open education.

1.4 Design Cases

This dissertation explores the possibilities of supporting open education through five design cases that are presented in the chronological order of designing them. The design cases are:

1. PILOT — multimedia learning resource template;
2. LeMill — web community for authoring and sharing of open educational resources;
3. EduFeedr — coordination tool for blog-based online courses;
4. LeContract — learning contract planning tool;
5. DigiMina — self- and peer-assessment tool.

First two design cases (PILOT and LeMill) are related to open educational resources. These studies were carried out in the context of school education in European countries. The third and the fourth design case (EduFeedr and LeContract) focus on open online courses. These were designed in the context of higher education and teacher training in Estonia. The final design case DigiMina is a designed for the assessment of educational technology competencies for Estonian teachers.

1.5 Research Questions

This dissertation is seeking answers for the following research questions:

Q1: What are the main design challenges related to the open education ecosystem?

Due to the very nature of wicked problems, part of the design challenges are revealed only during the design process, and in actual use. This study maps the design challenges that we have tackled in the design cases included in this dissertation. While these cases focus on designing online learning tools, similar design challenges may be relevant when designing learning scenarios or services for open education. However, due to the evolving nature of the open education ecosystem, this study cannot provide a complete set of design challenges.

Q2: What are the design patterns used in designing online learning tools and services for the open education ecosystem?

General recommendations for designing online learning tools for the open education ecosystem are provided in a form of *design patterns*. Design patterns are recurring solutions to common design challenges. The use of design patterns originates from architecture (Alexander, Ishikawa, & Silverstein, 1977), but design patterns have been successfully used also in several other fields such as software engineering, human-computer interaction and technology-enhanced learning. Design patterns recommended in this dissertation cover the main components of the open education ecosystem.

Q3: What kind of structure and components are needed to create the open education ecosystem?

As the "open education ecosystem" is a relatively new concept, there are a number of different interpretations. This study attempts to explore the open education ecosystem from the design perspective to determine what kind of structure and components are needed and how they should be integrated to create the open education ecosystem.

1.6 The Structure of the Dissertation

The dissertation is divided into seven chapters. In this chapter I have introduced the research context, the problem area, the aims of the study, and the research questions. Chapter 2 will give a theoretical foundation through literature review of four related research areas. Chapter 3 discusses the research design and methodology. Chapter 4 gives an overview of the five publications included in this dissertation. Chapter 5 presents five design projects of online services and learning tools that have been carried out during the study. Chapter 6 discusses the results and findings from the publications and design projects that form the basis of this study. Chapter 7 finally discusses the implications of the study and provides directions for future research.

2. Theoretical Framework and Key Concepts

This chapter discusses the theoretical background and clarifies the key concepts of the thesis. The first section of the chapter provides a brief history of using computers in education and explains some of the tools and technologies that are important for understanding the design cases on which the arguments in the thesis are built on. The second section discusses various perspectives related to open education, such as open educational resources, open and personal learning environments, open online courses, and open assessment. The third section presents the concept of digital ecosystems and aims to draw parallels between open education and digital ecosystems. The theoretical framework chapter ends with a section on designing online learning tools. The pedagogical principles underlying the design are embedded to sections discussing technology-enhanced learning, open education, and digital learning ecosystems. This chapter aims to enlighten the reader in the field of research in general and to locate the design cases included in the wider context.

2.1 Historical Perspective: Five Generations of Computers in Education

The history of computers in education is relatively brief. This dissertation omits the earlier developments such as the mechanical teaching machines by Sidney Pressey (in 1920s) and B. F. Skinner (in 1950s) (Benjamin, 1988), and focuses on the use of digital computers for learning. The first notable research initiatives of using computers in education date back to the early 1960s. Nicholson (2007) highlights Patrick Suppes at the Stanford University and Donald L. Bitzer at the University of Illinois as the most important early pioneers in the field that eventually became referred to as *computer-assisted instruction* (CAI).

Several authors have compared different paradigms of using computers in education, taking either the technological (Leinonen, 2010; Nicholson, 2007) or pedagogical perspective (Anderson & Dron, 2011). Jones (2011) has taken a narrower perspective by comparing the main paradigms of e-learning in higher education. From these comparisons, it is possible to distinguish five generations of using computers in education (see Table 1).

Table 1. Five generations of using computers in education (adapted from Anderson & Dron, 2011; Jones, 2011; Leinonen, 2010; Nicholson, 2007).

Era	Focus	Learning technologies	Learning activities
1959–1985	Computer assisted instruction	Personal computers, intelligent tutoring systems, artificial intelligence, programming tools	Drill and practice exercises, programming
1985–1993	Computer-based training	Educational desktop software, multimedia CD-ROMs	Reading, drill and practice exercises, educational games
1993–1998	Web-based training	Web sites, e-mail, discussion forums, chat	Reading, writing, discussing, testing
1998–2005	E-learning	Learning management systems, learning objects and repositories, computer-based assessment tools, video conferencing	Discussing, creating, constructing
2005–…	Technology-enhanced learning	Web 2.0, social software, personal learning environments, mobile devices, e-textbooks, interactive whiteboards, open educational resources, massive open online courses, learning analytics	Exploring, connecting, creating, evaluating, planning personal learning, reflecting

The beginning of each generation may be connected to an important turning point in the history of computing. It is, however, important to note that this is only one possible way of summarizing the history of computers in education. Each new paradigm has developed in a progressive manner on top of the earlier ones. The earlier paradigms have also stayed alive, although the main focus of research has shifted (Leinonen, 2010, p. 12). Reasons behind these paradigm shifts can also be related to science and education politics, for example the shift of focus from e-learning to technology-enhanced learning in the European context. These five generations of using computers in education are discussed in more detail in the following sections.

2.1.1 Computer Assisted Instruction

The first computer-assisted instruction systems were based on mainframe computers. The PLATO system, developed since 1959 at the University of Illinois, allowed teachers to prepare educational content and students to interact with that content (Alpert & Bitzer, 1970). Another early CAI system, developed since 1963 at the Stanford University, had a focus on drill-and-practice exercises for teaching mathematics and logic (Suppes, 1971).

Although these systems were limited by the existing technological constraints, initiators of both systems had a wider perspective on the use of computers in education. Suppes (1966) emphasized that computers had the potential to become an individual tutor that provided personalized instruction for each learner. Authors of the PLATO system, on the other hand, were critical about drill-and-practice exercises. They argued that the use of computers should allow for advanced learning strategies that involved student-controlled learning and supported the development of critical thinking (Alpert & Bitzer, 1970).

The focus of early CAI systems was on automating the teaching process. One of the most prominent critics of that approach was Seymour Papert, who envisioned that computers could be used “not in the form of machines for processing children, but as something the child himself will learn to manipulate, to extend, to apply to projects” (Papert, 1972). In late 1960s, Papert developed the Logo programming language that was widely used in schools in the United States and elsewhere.

Although the first initiatives were from 1960s, the era of computer-assisted instruction really took off in the mid-1970s with the introduction of personal computers. The main category of educational software developed at that time was the intelligent tutoring systems. The aim of these systems was to provide instruction and automatic feedback to drill and practice exercises without intervention from a teacher (Merrill, Reiser, Ranney, & Trafton, 1992).

In 1970s, the development of technology allowed researchers to focus on the media aspects of computing. Alan Kay and Adele Goldberg criticized the existing hardware and software. While it was successful from the computer science research standpoint, they pointed out that it lacked expressive power in order to make it useful for ordinary users. They envisioned the design idea of a personal media device named Dynabook and developed a related programming language, SmallTalk. Both of these were designed with education and creative tasks in mind. The SmallTalk language allowed the creation of software for drawing, animating pictures and generating music (Kay & Goldberg, 1977).

2.1.2 Computer-Based Training

By the mid-1980s a number of important innovations in computing reached the mass market. In 1984 Apple released the Macintosh computer that became the first commercially successful implementation of a window-based graphical user interface. Graphical user interface and availability of simple software for word processing, drawing and other common tasks made computers much more accessible for the general audience. One of the noteworthy applications from that period was HyperCard, that enabled non-programmers to create hypermedia content. It was widely used for educational purposes in late 1980s and 1990s. Constant advancements in processing power, storage space and multimedia capabilities led the way to the inclusion of CD-ROM drives in early 1990s. These possibilities were used for developing interactive multimedia-based courseware (Park & Hannafin, 1993) that was distributed on floppy disks and later on CD-ROM’s. Multimedia-based courseware offered a wider variety of learning activities than the previous generation of educational software and it became common to provide audio and video content, animations, interactive simulations, and educational games. This era is commonly referred to as *computer-based training* (Sims, 1988).

2.1.3 Web-Based Training

Another important turning point for learning technologies was the invention of the World Wide Web (WWW) by Tim Berners-Lee (Berners-Lee, Cailliau, Groff, & Pollermann, 1992). The technical architecture of the World Wide Web attempted to solve a number of issues that were present in earlier hypertext systems due to the lack of a common naming scheme for documents, common network access protocols and common data formats for hypertext. From the beginning, two underlying principles for the Web have been *universality* and *decentralization*. Subsequently, it has become important to emphasize these principles by talking about the open Web (Berners-Lee, 2010). Universality means that any web page can be linked to by using a unique address. Decentralization allows anybody who follows three basic web protocols to add a web page or create a link. These basic web protocols include HTML (HyperText Markup Language) for writing web pages, URI (Uniform resource identifier) for naming the documents and HTTP (Hypertext Transfer Protocol) for serving the web pages.

The WWW started to gain popularity around 1993 when the underlying technology was released to public domain. Although other Internet technologies such as e-mail were used to supplement courses already in 1970s (Harasim, 2000), it was the Web that made it possible to radically improve access to learning with the Internet. Initially the Web was used mainly in higher education, where teachers and professors were creating simple static web pages for publishing their course materials and sharing their browser bookmarks. The development of server-side technologies allowed the addition of interactive features such as discussion forums and chat. A common early implementation of using the Web in a university course was to provide students readings, guiding them to search information, to communicate with the teachers and other student over discussion forums and chat, and asking them to send their assignments to teachers over the Web or email. The simplicity of HTML language allowed also students to create their own web pages. However, the early Web had very limited multimedia and interactivity capabilities. First studies on the use of the Web for teaching and learning showed better access to up-to-date information, greater student input into their own learning process and a more individual approach to learning and assessment (Sloane, 1997). This era of initial experiments using the Web for learning purposes is known as *web-based training*.

2.1.4 E-learning

Innovative educators who recognized the new possibilities presented by the World Wide Web initially started developing web-based training systems. One of such initiatives was the WebCT system developed in the computer science department at the University of British Columbia (Goldberg, 1997). Positive reactions to these first experiments led many universities to explore how the Web could be used for providing distant education and support for traditional courses at the institutional level. By the end of the 1990s, a number of universities had started developing special web platforms that supported and managed online learning. This coincided with the start of the “dot.com” boom, in which companies had high economic expectations of using the Web in all kind of areas, including education. This era of hopes, hypes and rapid development of online learning technologies is most commonly referred to as the *e-learning* era. Both universities and companies had developed high expectations regarding e-learning: it was believed that with e-learning it would be possible to provide consistent training, reduce delivery time and information overload, increase learner convenience, improve tracking of learning progress and lower expenses (Welsh, Wanberg, Brown, & Simmering, 2003).

The end of the 1990s and the beginning of the 2000s was a very active period both for the development of e-learning technologies and for the advancement of pedagogical practices. Some of the important technologies developed in that era include learning management systems (LMS), learning objects, learning object repositories, computer-based assessment tools, and video-conferencing tools. In parallel with the development of learning platforms, active work was being carried on with the underlying learning technology specifications and standards, that dealt with metadata, content packaging and other interoperability issues.

These technological advancements also caused changes in the pedagogical practices. While delivery of rich content, discussions and computer-based assessment were dominant it was also common practice to provide activities with which learners could construct new knowledge (Rubens, Emans, Leinonen, Skarmeta, & Simons, 2005; Stahl, 2000).

2.1.5 Technology-Enhanced Learning

The most recent important paradigm shift in learning technologies took place around 2005. On one hand it was related to the technical developments that led to new discussion about the impact of Web 2.0 (O’Reilly, 2005), social software (Shirky, 2003) and advances in the mobile technologies of teaching and learning (Sharples, Taylor, & Vavoula, 2005). On the other hand and in parallel with the technical developments there was also a growing dissatisfaction with the dominant pedagogical practices in e-learning (Downes, 2005; Friesen, 2004; Laanpere, Põldoja, & Kikkas, 2004). Chan et al. (2006) refer to this new phase in the evolution of learning technologies as technology-enhanced learning. While e-learning had a focus on institutional technologies, TEL can be characterized by the use of personal web technologies and one-to-one computing where each learner has at least one portable computing device. The use of social software and personal learning environments that are controlled by the learner was seen as an alternative to learning management systems (Klamma et al., 2007; Wilson et al., 2007). The research on learning content has shifted from learning objects to open educational resources (D'Antoni, 2009; Duval, Verbert, & Klerkx, 2011) and e-textbooks (Sun, Flores, & Tanguma, 2012). Some of the recent research trends in TEL include massive open online courses (Kop, Fournier, & Mak, 2011) and learning analytics (Siemens, 2012). The shift towards personalization has enriched the pedagogical practices used in the era of TEL. Common pedagogical practices include exploring, connecting, creating and evaluating. The use of personal learning environments is strongly connected to self-directed learning where learners plan their personal learning goals and reflect on their process and outcomes.

2.2 Open Education

Openness in education is related to a number of aspects such as free and open access to learning resources and courses, open architecture of physical and virtual learning spaces, open approaches to designing learning activities and assessing learning outcomes. The following sections will introduce the historical background of the open education movement and different aspects of openness in education.

2.2.1 The Historical and Philosophical Background of Open Education

Providing free and open access to education is not a new idea. Openness and sharing of knowledge lie in the essence of academic culture. This section will shed light on some of the earlier movements that are have influenced the development of the open education movement, such as the public libraries and library movement, free adult education, distance education and open universities, the open classroom movement, hacker culture and free software movement.

During the fifteenth century, when the printing press was invented, libraries were typically connected to some religious or academic institution and not open to the general public. Although the earliest notes about public libraries date back to 1464 in Bristol (Orme, 1978), the public library movement really took off in 1850s. According to Black (1997), the first public libraries of that era were developed in the industrial towns and targeted for “good citizens and skilled workers”. By the time of the First World War there was a well-established structure of public libraries in the cities of the United Kingdom. Black (1997) notes that both the poor and the middle class groups of people equally used public libraries. Other Western countries followed the public library movement in the United Kingdom.

While the public library movement enabled anybody to have basic access to information, it was soon seen that there is also a need for flexible learning arrangements that are accessible specifically for adults. One of the first examples of free adult education is the folk high school movement in the Nordic countries (Toiviainen, 1995). The first folk high school was established in 1844 by the Danish pastor, poet and philosopher N. F. S. Grundtvig. The aim of the folk high schools was to provide popular education for peasants and other people who did not have good access to the formal higher education. The schools were typically founded by the educated people who wanted to contribute to the development of the local community. The folk high school movement spread from Denmark to Sweden, Finland and several other countries where it was financially supported by the government.

Folk high schools opened up education for new groups but still required physical presence from the learners. By the end of the nineteenth century, a number of large universities started offering some courses as correspondence courses in which printed course materials were sent out using the postal service. Sumner (2000) differentiates between three generations of distance education. The first generation of distance education, correspondence courses, had mostly one-way communication, since the feedback via the postal service was slow. The second generation of distance education started using new technologies such as broadcast media, cassettes and some limited two-way communication. This also led to the establishment of special distance education universities. For example, The Open University (United Kingdom) was established in 1969 and the Athabasca University (Canada) in 1970.

The third generation of distance education is based on computers and the Web. The open universities still play an important role both in offering distance education courses and in doing research on distance education technologies. Also, all major universities today are providing distance education courses over the Web. However, courses provided by the open universities are typically not free and the enrollment fee may be a barrier for some learners.

Simultaneously with the establishment of open universities, there was also a movement to change the teaching and learning practices in schools towards greater openness and learner-centeredness. The open classroom movement originated from British schools but gained momentum in the United States between the late 1960s and late 1970s (Cuban, 2004). The open classroom movement tried to change both the teaching practices and the physical setup of the learning spaces. It promoted group work over whole-class lessons, blending of different subjects and discovery of new knowledge by the learners themselves. The classrooms were rearranged to have different group work areas instead of rows of desks. The open classroom movement is important in the context of this dissertation, since it had a wider perspective on openness in education. While earlier movements focused on providing free or improved access to education, the open classroom movement aimed to change the educational practices and the learning environment. However, the peak of the open classroom movement did not last for a long time. Cuban (2004) sees changes in American public opinion as a reason for the quick rise and decline of the open classroom movement. In the 1960s people felt a need for greater creativity in order to compete with the Soviet Union, while in the 1970s the society was divided because of the Vietnam War and became worried that the academic standards of schools had declined.

Some thinkers of that period were questioning the need for a school as an institution at all. The most radical critic of the educational system was an Austrian philosopher Ivan Illich who gained attention with his book “Deschooling Society” (Illich, 1971/2011). Illich argued that a good educational system should have the following three purposes: “it should provide all who want to learn with access to available resources at any time in their lives; empower all who want to share what they know to find those who want to learn it from them; and, finally, furnish all who want to present an issue to the public with the opportunity to make their challenge known." He proposed the idea of "learning webs" that would consist of four types of networks (Illich, 1971/2011, p. 78–79):

- reference services to educational objects;
- skill exchange networks for people who are willing to share their experience with others;
- peer-matching networks for finding other learners interested in the same topic;
- reference services to educators.

The open education movement is also influenced by the hacker culture that emerged in the 1960s in computer science departments where skilled students and staff tried to use the power of computing in new ways. Himanen (2001) discusses hackers' ethical understandings and concludes that for hackers, social motivations such as being part of a community and getting recognition for their contribution were more important than direct monetary benefit. Therefore, a lot of hackers were critical of the commercialization of software that made the software less affordable and limited possibilities to make modifications to the software.

The free software movement and the Free Software Foundation established by Richard Stallman in 1985 focuses on promoting universal freedoms related to creating, using, modifying and distributing the software. In 1998, the Open Source Initiative was established and a more business-friendly concept of *open source software* was taken into use. These two movements are often referred to together as *free/libre/open-source software*.

The hacker culture lead to a number of technical, sociocultural and legal innovations such as developing various competing versions of the software from the same code, using collaboration-based authoring models and releasing software under open licenses (Lin, 2007). Although hacker culture is mainly associated with free software, hackers also valued free access to knowledge. A good example is the Project Gutenberg[1] that was started in 1971 by Michael Hart at the University of Illinois (Hart, 1992). Hart used his access to a mainframe computer to set up a public archive of electronic books that were no longer under copyright. Project Gutenberg now hosts a collection of over 50,000 free e-books and can be seen as one of the inspirations for the open educational resources movement.

Since early 2000s there has emerged a number of loosely connected open movements and communities that all together form the free culture movement (Fuster Morell, 2011). In addition to the open education movement, these include movements and communities interested in open source, open data, open access, open science, open knowledge, and open policies. All of these movements share a common set of values and act independently and together to influence the authorities to reform the current intellectual property regime. The following sections will introduce the main initiatives of the open education movement.

[1] http://www.gutenberg.org

2.2.2 Open Educational Resources

While the main focus of learning objects research in the 1990s was on developing infrastructure for sharing and reuse of content (repositories, metadata specifications), some researchers also turned their attention to copyright issues that hindered the large scale reuse of learning objects. In 1998 David Wiley introduced the idea of *open content* and released the first OpenContent License[2]. According to Wiley and Gurrell (2009), "open content was an attempt to apply the pragmatic arguments made in favour of open source software to educational materials and other content, including scholarly research, music, literature and art."

In 2001 Lawrence Lessig and other open content activists founded Creative Commons. This organization created a set Creative Commons (CC) licenses that are used worldwide for sharing and remixing open content. There are six main licenses that allow authors to reserve a different extent of rights. For example, some CC licenses allow commercial use and some do not. While the CC licenses have provided a flexible framework for sharing open content, there are also issues such as license incompatibility and the unnecessary use of non-commercial restriction (Keats, 2006).

In 2002 UNESCO organized a meeting to discuss the recent developments related to free and open sharing of educational content. The participants of the meeting decided to use a term *open educational resources* to refer to educational resources that are free for use and adaptation (UNESCO, 2002). During the years a number of definitions have been proposed for OER (Gurell, 2008, p. 2; OECD, 2007, p. 30; Schaffert & Geser, 2008; UNESCO, 2002, p. 24; UNESCO, 2012; The William and Flora Hewlett Foundation, n.d.). This dissertation follows the latest definition from the UNESCO Paris 2012 OER Declaration which defines OER as "teaching, learning and research materials in any medium, digital or otherwise, that reside in the public domain or have been released under an open license that permits no-cost access, use, adaptation and redistribution by others with no or limited restrictions" (UNESCO, 2012).

David Wiley has attempted to define OER's through the rights that are granted for the user. Initially the framework included four 'R's of openness (Hilton, Wiley, Stein, & Johnson, 2010), later it was extended to include five 'R's (Wiley, 2014): retain, reuse, revise, remix, redistribute. These five R's should give the authors and users control over creating and using open educational resources. Wiley defined "reuse" as the most basic level of openness that allows anybody to use content in an unaltered way. "Revising" enables people to modify the content and "remixing" involves combining two or more resources. "Redistributing" covers the right to share copies of the original, revised and remixed versions. "Retaining" access to the content was added to the framework in 2014 since many online services make it difficult for authors and users to have a complete control over their content.

Common types of OER online initiatives include databases of full set of materials for a specific courses (also known as OpenCourseWare initiatives), re-

[2] http://web.archive.org/web/20140709203845/http://www.opencontent.org/opl.shtml

positories of individual OER's, and referatories that link to the OER's that are hosted elsewhere. Connexions[3] (now called OpenStax CNX) was one of the first OER repositories (established in 1999) that allowed users to create web-based content and provided limited features for collaborative authoring. MIT OpenCourseWare[4] (established in 2002) provides complete sets of course materials with learning resources, assignments, recommended readings, syllabus, and also in some cases, recorded video lectures. Other well-known initiatives include Curriki[5] repository (established in 2006) and OER Commons[6] that contains both a referatory and an authoring tool (established in 2007). WikiEducator[7] and Wikiversity[8] (both established in 2006) are attempts to use wiki as a collaboration platform for creating open educational resources, and Wikimedia Commons[9] is a repository of digital media for learning purposes.

A number of challenges for large-scale adoption of open educational resources can be identified from literature (Atkins et al., 2007; Browne, Holding, Howell, & Rodway-Dyer, 2010) and the experience of existing OER initiatives. These challenges are related to authoring, quality, legal issues, awareness, and sustainability of OER's. Regarding the authoring, OER's can be created either by institutions or by individuals. Weller (2010) refers to these as *big* (institutionally created) and *little* (individually created) OER's. Furthermore, it is possible to have peer-produced and individually created resources. However, the OER community lacks extensive examples of peer production such as Wikipedia. Collaborative features and processes of authoring tools have been found as critical issues for supporting the co-authoring of OER's (Petrides, Nguyen, Jimes, & Karaglani, 2008). There is also an issue of motivating educators to publish their existing resources as OER's. Creating learning resources by individuals and through peer production raises the question of quality. Camilleri, Ehlers, and Pawlowski (2014) see quality of OER's as a confluence of efficacy, impact, availability, accuracy, and excellence. On the one hand, it is challenging to incorporate quality assurance mechanisms into the peer production process without complicating the workflow. On the other hand, there is also the possibility of identifying high quality resources during the use time through learning analytics and social recommendations. A group of challenges is related to legal issues such as license incompatibility, checking for potential copyright infringements, and limited understanding of copyright principles among the educators. There is also a greater need to raise the awareness of learners, educators and policy makers about open educational resources. Finally, there is the challenge of sustainability. This is an issue both at the resource level where authors may neglect updating the resource and at the initiative level where a lack of funding may threaten the sustainability.

[3] http://cnx.org

[4] http://ocw.mit.edu

[5] http://www.curriki.org

[6] http://www.oercommons.org

[7] http://wikieducator.org

[8] http://www.wikiversity.org

[9] http://commons.wikimedia.org

2.2.3 Open and Personal Learning Environments

The initial focus of the open education movement was on making the learning resources openly available. However, learning content plays only a partial role in the learning process. With the growing interest in social software (Shirky, 2003) and Web 2.0 (O'Reilly, 2005) researchers and practitioners in education have started to reconsider more and more the practices of teaching and learning in the context of using the Internet. Blogs and wikis were seen as especially promising social software tools for learning (Augar, Raitman, & Zhou, 2004; Williams & Jacobs, 2004).

The growing use of social software in learning highlighted the pedagogical limitations of many learning management systems. LMS's were criticized because their design was often based on a simplistic understanding of teaching and learning (Coates, James, & Baldwin, 2005; Dalsgaard, 2006). In LMS, all the tools necessary for running the course were integrated into one standalone system. While this approach had certain benefits for managing the courses (course descriptions, student enrollment, course schedules, statistics about student activity, etc.), it also had important limitations by enforcing certain pedagogical practices. Often, the focus was on presenting sequenced content and providing simple assessment tests that can be automatically corrected. The social features of LMS's were typically limited to discussion forums. According to Dalsgaard (2006), learning management systems do not effectively support social constructivist learning in which learners take a higher responsibility in governing their learning and collaborative activities with other learners. For those kinds of learning scenarios, combining a set of social software tools that support the needs of specific learning activities would be a more flexible solution rather than using an LMS that provides a fixed structure for learning activities.

Wilson et al. (2007) proposed personal learning environments as an alternative design to the learning management systems. They described PLE as an open system where the focus is on coordinating connections between the user and services instead of integrating tools and data into a single system. This kind of learning environment would have symmetric relationships between users and does not position the teacher at the center. Technically, PLE's rely on open Internet standards and lightweight application programming interfaces (APIs) instead of complex e-learning standards. Regarding the learning content, PLE's would use open content and encourage remix culture. PLE's would have a personal and global scope instead of organizational scope that is typical for LMS's.

While a set of connected social software tools make up an important part of the PLE, the concept is wider than just a collection of software tools. Johnson and Liber (2008, p. 3) argue that personal learning environments could lead to "a learner-driven model of education, where the traditional provider-centric role of institutions is challenged." Väljataga and Laanpere (2010) see PLE's as a way to give a higher degree of control to learners over their learning process. They propose, that learners should not only be able to select tools for their

PLE, but also set their personal learning goals, decide on the required resources, learning strategies, and criteria for evaluating the learning outcomes.

In the context of open education, an important characteristic of personal learning environments is openness. When discussing the openness of learning environments and the Web in general, several authors have used the *walled garden* metaphor (Anderson & Wolff, 2010; Berners-Lee, 2010; Mott & Wiley, 2009). In a typical LMS, each course can be seen as a walled garden. Students need to be enrolled to access the course, there is little or no knowledge sharing between the courses and with the open Web. PLE's are based on social software tools where the communication and activities are often visible for everybody. However, the use of social software and Web 2.0 tools does not necessary guarantee openness. Large social networking sites have also become walled gardens that isolate the information posted by their users from the open Web. They break the principle of universality of the open Web, since often it is not possible to link to a specific piece of information in the social networking site.

Although the openness of learning environments raises some privacy concerns (Weippl & Ebner, 2008), there are a number of undeniable benefits. McLoughlin and Lee (2007) see the possibility to connect to other people anywhere in the world, collaborative information discovery and sharing, collaborative content creation, and the possibility of aggregating information, as the main benefits provided by the open nature of social software. Several authors have also used the concept of *open learning environments* (Baker & Surry, 2013; Conde, Garcia, Casany, & Alier, 2010). Baker & Surry (2013, p. 190) define the open learning environment as "an organic open system that is comprised of a variety of unique components found in the environment, the instructor, and the student." They argue that open learning environments could be used for opening up traditional education models, providing space for focusing on specific topics, and creating new alternative education models.

2.2.4 Open Online Courses

One way to challenge traditional education models is to use open learning environments to enable anybody to take part in formal higher education courses. In the fall of 2007, David Wiley was conducting the *Introduction to Open Education*[10] undergraduate course at the Utah State University. Wiley decided to experiment by allowing anybody who was interested in the topic to enroll to the course free of charge. The only requirement was to have a blog for posting the weekly assignments. Enrollment to the course was simply handled by a wiki page where people added their blog addresses. The course was offered in three different ways: for-credit, non-credit, and informal. For-credit participants had to agree with a professor in their home university to receive credits for the completion of the course. Non-credit students participated in the course without grading but were able to receive a certificate of completion in

[10] http://web.archive.org/web/20071215133745/http://opencontent.org/wiki/index.php?title=Intro_Open_Ed_Syllabus

the end. Informal participants attended the course completely on their own. All together, about 50 participants enrolled to the course (Fini et al., 2008).

For the spring term in 2008, this format was developed further separately by Alec Couros (Couros, 2010) and Teemu Leinonen (Leinonen, Vadén, & Suoranta, 2009). Couros, who was giving the *EC&I 831: Social Media & Open Education*[11] course at the University of Regina, identified that in these kind of open courses it is critical to support the development of the participants' personal learning networks. In order to do that, he introduced collaborative assignments in addition to individual blogging and synchronous sessions to build group identity. Leinonen, who was organizing the *Composing free and open online educational resources*[12] online course at the University of Art and Design Helsinki[13], used Wikiversity as a platform for developing and running the course. He encouraged the course participants to already have the course content, program and assignments co-edited prior to the start of the course. The author of this dissertation acted as a co-facilitator in Leinonen's course.

These first open online courses provided some insights both on the possibilities and limitations of blog-based open online courses. The genre of blog-based open online courses includes the teacher writing assignments to the wiki or course blog and students writing responses to these assignments in their personal blogs. Students obtain a wider perspective on the topic by reading and commenting on each other's blog posts. Blogs provide a simple way of opening up course participation and the learning environment for informal participants. Use of blogs has a number of pedagogical benefits such as motivating learners, fostering collaboration, enabling learners to get feedback to their ideas from peers, and enhancing critical thinking (Goktas & Demirel, 2012). However, the simple structure of a central wiki, course blog and personal blogs was not scalable for a large number of participants. Activities such as managing the lists of active participants and submitted assignments required extra work from the facilitator. Also, the discussions taking place in the comments were fragmented between the different blogs (Efimova & de Moor, 2005; Põldoja, Duval, & Leinonen, 2016).

An open online course with a large number of participants requires a different instructional design and a larger variety of tools. In the fall of 2008, George Siemens and Stephen Downes organized an open online course *Connectivism and Connective Knowledge*[14] (CCK08) that attracted approximately 2,200 participants. The course was based on connectivist design principles (McAuley, Stewart, Siemens, & Cormier, 2010), which focus on knowledge sharing between the participants instead of a fixed set of assignments. Due to the nature of the course, a large variety of online tools were used in addition to wiki and blogs (Fini, 2009). The participants started calling these types of courses MOOCs – massive open online courses. Later the MOOC format was

[11] https://eci831.wikispaces.com

[12] https://en.wikiversity.org/wiki/Composing_free_and_open_online_educational_resources

[13] In 2010, University of Art and Design Helsinki merged with two other universities and formed Aalto University. Currently the school is named Aalto University School of Arts, Design and Architecture

[14] http://web.archive.org/web/20090711085816/http://ltc.umanitoba.ca/wiki/Connectivism_2008

picked up by some of the leading universities. For example, the *CS221: Introduction to Artificial Intelligence*[15] course at the Stanford University had more than 160,000 enrolled participants (Rodriguez, 2012). This course did not use social software tools but had a special platform with lecture recordings and assignments. Since then, a number of special platforms such as Coursera[16], edX[17] and Udacity[18] have been developed for MOOCs. It can be argued, that courses running on these platforms are not "open" as traditionally thought of being open in the context of the open Web. On these MOOC platforms, learners have to enroll to access course content, which is often also not openly licensed. Also, these platforms have started to provide paid courses in addition to free MOOCs. Wiley (2015) has even criticized that "MOOCs, as popularized by Udacity and Coursera, have done more harm to the cause of open education than anything else in the history of the movement".

There is a growing body of research that focuses on the pedagogical, technological and organizational aspects of MOOCs (Liyanagunawardena, Adams, & Williams, 2013). Most often, the researchers distinguish between the connectivist cMOOCs and Stanford-like xMOOCs (Rodriguez, 2013). However, there are a wider variety of different types of open online courses. Conole (2014) has proposed a framework of 12 dimensions (openness, massiveness, use of multimedia, degree of communication, learning pathway, quality assurance, amount of reflection, certification, formal learning, autonomy, diversity) for classifying open online courses.

Two design cases included in this dissertation were developed in the context of blog-based open online courses in Tallinn University. Blog-based open online courses can be typically characterized by a high degree of openness and reflection, but a low degree of massiveness. In Tallinn University, these were formal university courses where the informal participants could participate in online activities by through their blogs. In the Estonian context, this typically meant a small number of informal participants in addition to the university students. In addition to online activities, there were typically also some face-to-face seminars for the university students. Design challenges related to this kind of blog-based open online courses are discussed by Väljataga, Põldoja, and Laanpere (2011). Due to a small number of participants, creating and sustaining community gravity needs a careful planning. The decentralized nature of blog-based learning environments raises challenges in monitoring participation and content flows. There is also the question as to what extent the learning content and activities can be developed beforehand. Finally, open online courses that take place in blogs require a different approach on feedback and assessment.

[15] http://web.archive.org/web/20111203044829/https://www.ai-class.com/

[16] https://www.coursera.org

[17] https://www.edx.org

[18] https://www.udacity.com

2.2.5 Assessment and Recognition of Open Learning

Open online courses and learning activities that take place in the open Web introduce new kinds of challenges for assessment and recognition. Learners have a flexible opportunity to take part in various open online courses. It is common for them to not complete the whole course but participate only in those activities that they find most relevant. Also, learners can study independently using open educational resources. These new learning opportunities raise a question of recognizing the skills and competencies obtained through open learning. Some xMOOC platforms have built in computer-based assessment tools and provide certificates for learners who have completed the course. MOOCs offered by universities may provide university credits at the completion of the course. There are also initiatives by institutions such as Saylor Academy[19] and OERu[20] that are working with partner universities to provide assessment and credits for open learning. These models mainly attempt to copy formal recognition mechanisms that are present in higher education.

Some assessment issues are specific to blog-based open online courses. Feedback for blog posts is typically given via comments. However, public comments are not suitable for grading students' work, since grades are private data. Students post their submissions typically as reflective blog posts. This means that blog-based open online courses cannot rely on computer-based assessment as it is done with xMOOCs. It is not realistic to expect the facilitator to give feedback for each blog post and therefore it is crucial to involve learners through peer-review and peer-assessment activities. Also, as it is common in other types of open online courses, informal participants often complete only some assignments.

One solution for assessing and recognizing open learning is the use of open badges (OBs) (Jovanovic & Devedzic, 2015). Open badges infrastructure allows any organization or educator to issue digital badges for learners who have completed the assessment tasks. Technically, badges are digital images that have a set of encrypted metadata such as the issuer, criteria, and evidence. Learners can collect earned badges to the digital backpack and display them on their social media profiles. As the OB technology is relatively new, there is still limited empirical research on using open badges. Some of these studies focus specifically on using open badges in blog-based open online courses. For example, the study of Santos et al. (2013) has revealed that the use of OBs together with a learning analytics dashboard helps to motivate learners. Haug, Wodzicki, Cress, and Moskaliuk (2014) also studied motivational issues and found out that those learners who aimed to earn badges had smaller decrease of activity during the course than learners who were not interested in badges. Põldoja and Laanpere (2014) concluded that the use of badges could solve some of the assessment issues such as private grading in blog-based courses and provide a greater choice of learning pathways.

[19] http://www.saylor.org

[20] http://wikieducator.org/OERu

Issuing certificates for completed MOOCs and providing open badges are organizational and technical solutions that are more related to recognition than assessment. As pointed out by Wiley (2015), there is still little done in the field of open assessment. Wiley sees sharing open competencies and performance assessment tasks as one solution for assessment related issues. The benefit of performance assessment tasks is that these cannot be cheated like computer-based assessment tasks, thus they can be openly shared.

From the pedagogical perspective, open assessment could be associated also with learner-centered assessment methods such as self-assessment and peer-assessment. For example, self-assessment could be used in combination with the personal learning contract method (Anderson, Boud, & Sampson, 1996) in blog-based open online courses. In this approach, learners set their personal goals and evaluation criteria in the learning contract and use these to evaluate their achievements at the end of the course. Peer-assessment has been suggested as a widely applicable assessment method for different types of open online courses. This is especially true with large MOOCs that where it is virtually impossible to get direct feedback from the facilitator (Suen, 2014).

2.3 Open Education as an Ecosystem

Early online platforms were typically self-contained independent systems, for example learning management systems such as WebCT. With the emergence of social software and Web 2.0 in mid 2000s, people started to talk about *ecosystems* in addition to *platforms*, when referring to digital systems. The ecosystem metaphor was taken into use to emphasize the possibility of integrating and connecting software with other services. The following sections will introduce the concept of *digital ecosystems* and present some examples from actual practice. More specifically, this theoretical overview will discuss technology-enhanced learning and open education from the perspective of digital ecosystems.

2.3.1 Digital Ecosystems

The concept of digital ecosystems appeared in mid 2000s. During that period, it was often discussed from the biological perspective, as the scholars drew parallels between natural and digital ecosystems. In order to understand, how digital ecosystems are similar to natural ecosystems, the main concepts of natural ecosystems have to be explained first.

Natural ecosystem could be defined as “the biological community together with the abiotic environment in which it is set” (Begon, Townsend, & Harper, 2006, p. 499). The natural environment is comprised of different ecosystems, for example seas, rivers, lakes, forests, fields, deserts and urban ecosystems. Each ecosystem consists of a *community* of living organisms and an area where they live. The area inhabited by the species is known as *habitat*. The community consists of *populations*, which are made of individuals of the same species. Each habitat could be divided to *microhabitats* where specific populations live. Populations together with the microhabitats in which they live form *niches*. A niche could be understood as a summary of the organism's tolerances and requirements. For example, a niche in the sea ecosystem could have a temperature, pH level and salinity, all of which are suitable for specific populations inhabiting this microhabitat (Begon et al., 2006). The community of living organisms is the biotic part of the ecosystem. Environment (e.g. air) and its characteristics (e.g. temperature, humidity) are the abiotic part of the ecosystem. The relationship between the main concepts related to natural ecosystems is presented in Figure 1.

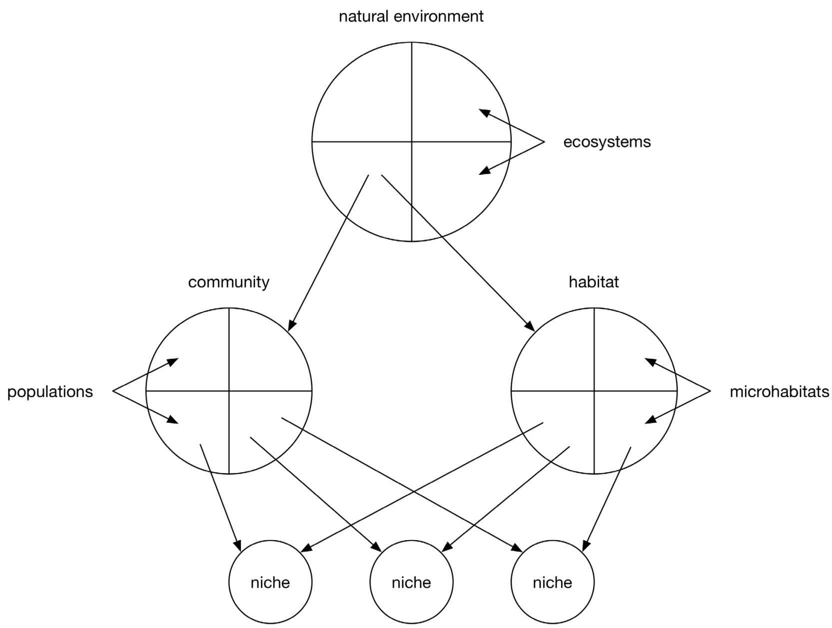


Figure 1. Main concepts of natural ecosystems (redrawn from Briscoe, Sadedin, & De Wilde, 2011)

In one of the early publications about digital ecosystems, Chang and West (2006) discuss the similarities between natural and digital ecosystems and summarize four essences of an ecosystem that are present in both types of ecosystems:

- interaction and engagement;
- balance;
- domain clustered and loosely coupled species;
- self-organization.

Interaction and engagement takes place between the species for mutual benefit. Ecosystems keep balance between the species in order to sustain harmony and stability. Species are domain clustered and loosely coupled groups, that have a similar culture, habits, interests and objectives. Finally, species have the ability to self-organize by being independent and having the self-defense mechanisms. Based on these essential characteristics, Chang and West (2006) proposed to define digital ecosystem as "an open, loosely coupled, domain clustered, demand-driven, self-organising agents' environment, where each specie is proactive and responsive for its own benefit or profit". Later, Brisco and De Wilde (2009) have proposed a more simplified definition that sees digital ecosystems as "distributed adaptive open socio-technical systems, with properties of self-organisation, scalability and sustainability, inspired by natural ecosystems".

Digital ecosystems are discussed in academic writings at various levels of detail. Some researchers go to great depths in analyzing digital ecosystems as digital counterparts of natural ecosystems (Briscoe et al., 2011), while many others remain at the metaphorical level. Pournaras and Miah (2012) distinguish between two types of research regarding digital ecosystems. *Metaphor-inspired* research areas have their own terminology but introduce some concepts inspired by the ecosystem metaphors. Examples of metaphor-inspired computing areas include peer-to-peer computing, cloud computing, agent-based computing, and grid computing. *Metaphor-defined* areas of computing rely more explicitly on biological concepts such as self-organization, self-healing, evolution and sustainability. Some metaphor-defined computing fields include autonomic computing, organic computing, evolutionary computing, and green computing.

This dissertation belongs to the metaphor-inspired approach, which has certain benefits for the design. Metaphors have been found useful in early phases of the design process, especially when dealing with wicked or ill-defined design problems. In these kinds of situations, metaphors help the understanding of unfamiliar problems in terms of known contexts. Thus, the use of metaphors could help to come up with innovative design solutions (Casakin, 2007).

From the cloud computing perspective, digital ecosystems can be associated with cloud services, user communities and big data. According to Blanke (2014, p. 22), "digital ecosystems describe the connections between networks of platforms, software and users". Blanke sees *crowds* as the equivalent of populations in natural ecosystems. The role of crowds is to make the large scale authoring, processing and analysis of digital content easier. Depending on the content, these are the tasks that cannot be easily done by the computers. This is associated with the idea of crowdsourcing (Howe, 2006), which means involving crowds of individuals in tasks that require a lot of time or other resources. Blanke suggests *clouds* as the equivalent of habitats and microhabitats in natural ecosystems. Clouds are not simply storage spaces but platforms on which various applications are built on. *Services and applications* in digital ecosystems are the same as niches in natural ecosystems. A service or application is built on a cloud platform and used by certain crowds. This conceptualization of digital ecosystems is depicted in Figure 2.

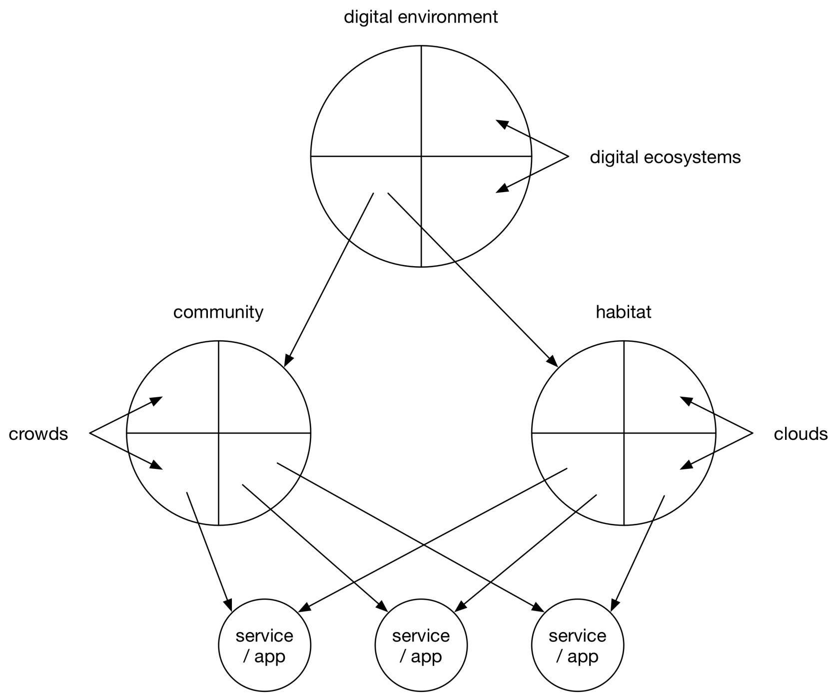


Figure 2. Main concepts of digital ecosystems (based on Blanke, 2014, p. 24)

This view on digital ecosystems also emphasizes the important role of digital content. Blanke (2014) uses the term *digital assets*, when referring to the content in digital ecosystems. At the generic level, digital assets can be understood as digital objects that have an economic, social or cultural value. In order to realize these values, digital assets are described with metadata and usage rights that enable their consumption. Open educational resource that is described with appropriate metadata, published under a Creative Commons license, and distributed through a repository, would be a good example of a digital asset.

Technically, digital ecosystems are related with service-oriented architecture (SOA) (Brisco et al., 2011). In service-oriented computing, services are used as fundamental components for developing software applications. Services can be understood as self-contained technology neutral software components that are used by other applications through a communication protocol (Papazoglou, 2003). SOA allows the combination and use of existing software components when creating new applications. Many Web 2.0 services provide APIs that enable other developers to build new applications for interacting with content and data. This may lead to an ecosystem of connected services and applications. A good example is Twitter, that has a large number of applications and services that use its APIs, both on Web and on mobile platforms.

On a practical level, many widely used online services could be discussed as digital ecosystems. For example, it is possible to talk about the "Google ecosystem", "Facebook ecosystem", "Apple ecosystem" or "Wikipedia ecosystem". In the case of Google, there are a large number of individual applications that are all loosely joined. We can see, how Google is trying to keep balance in the ecosystem by coming up with new applications, redesigning existing applications and sometimes closing applications that do not fit anymore with their goals. Facebook is partly an example of a walled garden where user crowds contribute to the development of additional applications that work inside Facebook. However, some parts of Facebook are open to the Web and external services. The "Apple ecosystem" is built around the hardware, software and services developed by the company. This has enabled the company to achieve a high level of interoperability between the Apple devices and software. However, Apple could be also criticized for having built a closed ecosystem that intentionally limits interoperability with competitor services and devices. Wikipedia and other wiki-based communities run by the Wikimedia Foundation could be seen as an example of an open ecosystem. Wikimedia Foundation provides the infrastructure that enables user crowds to develop multilingual wiki projects. The developed content is available under a free license that allows reuse by other people and services.

2.3.2 Digital Learning Ecosystems

Ecosystem thinking has inspired the design of various types of information systems. In the context of this dissertation, it is important to look at the ecosystems approach on technology-enhanced learning. As pointed out by Gütl and Chang (2008), the increasing complexity of modern learning setups requires appropriate models and architectures for communicating conceptual ideas and turning them into practical implementations. It is common, that a number of different systems are used in a typical learning scenario for creating and distributing learning content, participating in group work and discussions, reflecting on the personal learning, and managing the course.

Several authors have proposed concepts such as *e-learning ecosystem* (Chang & Guetl, 2007; Uden et al., 2007), *digital learning ecosystem* (Ficheman & de Deus Lopes, 2008; Laanpere, Pata, Normak, & Põldoja, 2012) or *digital teaching and learning ecosystem* (Reyna, 2011). Their interpretations differ mostly in details, how they model the biotic and abiotic component of the ecosystem. From these studies, Chang and Guetl (2007) have a most systematic approach on modeling the e-learning ecosystem. Based on Pickett and Cadenasso (2002), they recommend five characteristics for describing particular instances of ecosystem models:

- the biotic and abiotic components and their level of aggregation;
- the temporal extent and the temporal and spatial scale of the system;
- the physical boundaries of the system;
- the type and extent of relations and interaction between the ecosystem components;
- constraints on system behaviors.

Following these characteristics, Chang and Guetl (2007) propose the concept of *learning ecosystem* that consists of learning stakeholders (learners, teachers, school administration, content providers, parents, etc.) and their communities as the biotic part and learning utilities (content, tools) as the abiotic part of the ecosystem. In order to describe the physical and logical borders of the system, Chang and Guetl (2007) use the concept of *learning environmental boundaries*[21]. For example, the boundaries of blog-based open online courses are defined by the use of blogs, feed readers, and external social media platforms that allow content to be embedded into blog posts. Both internal relations between the ecosystem components and external forces influence the behavior of the ecosystem. These internal and external influences are specified as *learning ecosystem conditions*. For each concrete model of the learning ecosystem, also the temporal extent and the temporal and spatial scale also have to be specified. Simplified representation of the learning ecosystem is presented in Figure 3. This representation could be used as a basis for visualizing learning ecosystems in different contexts, including open education.

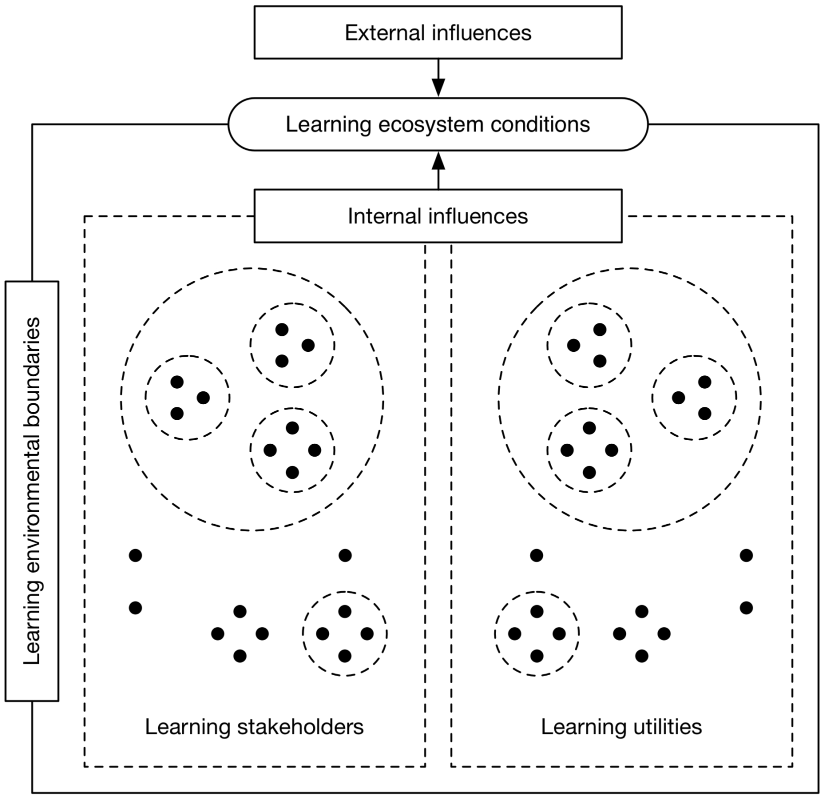


Figure 3. Simplified representation of the learning ecosystem (redrawn from Gütl & Chang, 2008)

Chang and Guetl (2007) suggest that while the concept of the learning ecosystem could be used to describe any physical or virtual learning setting, it is pos-

[21] In a later publication, Gütl & Chang (2008) use the concept of *learning environmental borders* in parallel with *learning environmental boundaries*. These two concepts should be understood as synonyms. For clarity, this dissertation is using the concept *learning environmental boundaries*.

sible to narrow it down to specific domains such as e-learning. In this context, they use the concept of e-learning ecosystem (ELES). This allows the identification and study of characteristics that are specific to ELES, such as learning communities and other stakeholders, digital learning tools and conditions specific to e-learning. This dissertation uses the *digital learning ecosystem* (DLE) as a general concept for describing learning ecosystems in TEL domain. This concept also covers e-learning ecosystems, but is more in line with recent developments in TEL.

Laanpere, Põldoja and Normak (2013) argue that DLE's represent the third generation of learning systems. In this interpretation, offline learning systems (educational desktop software, multimedia CD-ROM's) and virtual learning environments (LMS's, computer-based assessment tools, etc.) stand as previous generations of learning systems. Specific software architecture, pedagogical foundations, content management approach and affordances characterize all three generations of learning systems. These main characteristics are summarized in Table 2.

Table 2. Generations of learning systems (based on Laanpere et al., 2013)

Dimension	Offline learning systems	Virtual learning environments	Digital learning ecosystems
Software architecture	Desktop software	Single-server monolithic system	Cloud architecture, SOA, mobile clients
Pedagogical foundation	Operant conditioning	Pedagogical neutrality	Social constructivism, connectivism
Content management	Content was integrated	Separated from software, reusable	Web-based, embeddable, located outside, rich metadata, openly licensed
Dominant affordances	Presentation, drill, test	Presentation, assignments	Reflection, sharing, remixing, tagging, mashups, recommenders

While VLE's were typically built as single-server monolithic systems, DLE's consist of multiple could applications that are based on service-oriented architecture. Pedagogically, DLE's can be associated with social constructivism and connectivism (Anderson & Dron, 2011). Learning content is typically located in the open Web and can be embedded in different learning tools used in the ecosystem. Dominant affordances of DLE's include reflection, sharing, remixing, tagging, mashups and recommenders.

When looking at these characteristics, it is possible to argue that open education could be seen as one example of digital learning ecosystems. Also it is possible to look at specific areas of open education (open educational resources, open online courses) as independent examples of digital learning ecosystems. The following section discusses some of the ecosystem approaches in open education.

2.3.3 Ecosystem Perspectives on Open Education

In June 2007, a group of open education scholars and activists gathered for the education track at the iCommons Summit[22]. Among other topics, the participants discussed the open education movement, suggesting it could expand its focus beyond content. One of the concepts that evolved in the discussions was the open education ecosystem. Schmidt and Surman (2007) made a summary of these discussions. Based on the sketches drawn by the participants, they visualized the structure of the open education ecosystem. In this interpretation, key components of the open education ecosystem included people, content, tools, communities and organizations. In addition to these five key components, there were processes that described the relations and interactions between the components of the ecosystem. The behavior of the ecosystem is influenced by a loosely agreed set of common values. Schmidt and Surman (2007) do not refer to the research on digital ecosystems. However, their model of the open education ecosystem could be mapped according to the learning ecosystem model developed by Chang and Guetl (2007). This mapping is presented in Figure 4.

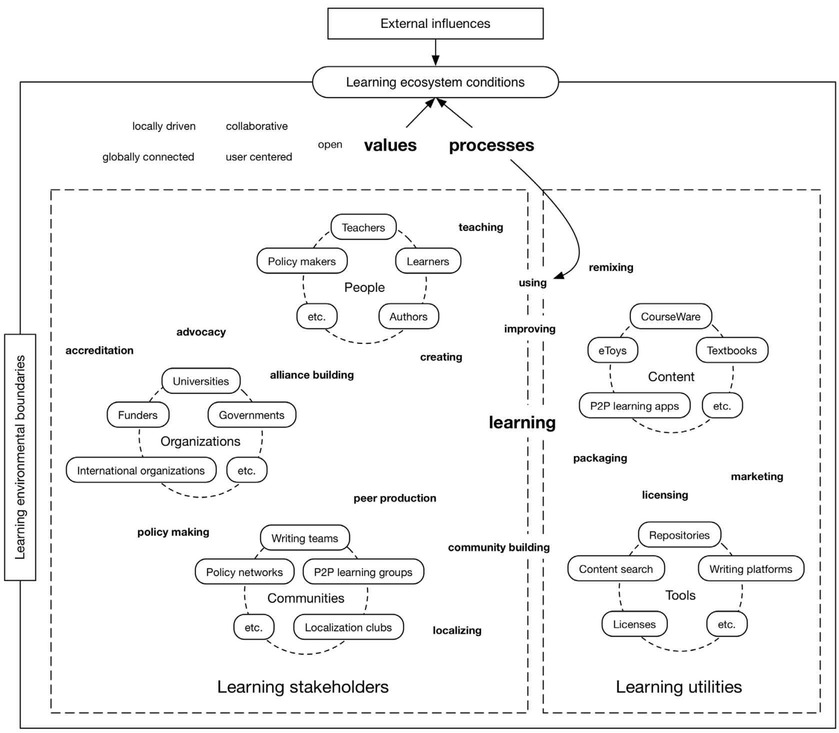


Figure 4. Open education ecosystem as a learning ecosystem (based on Schmidt & Surman, 2007; Gütl & Chang, 2008)

[22] iCommons Summit was the annual meeting of Creative Commons and other commons-oriented movements

When examining this scheme of open education ecosystem, it is important to keep in mind, that this was developed at the time when the open education movement focused mostly on content. People, organizations and communities would belong to the biotic part of the ecosystem. The abiotic part of the ecosystem is made up of content and tools. Schmidt and Surman (2007) did not discuss the borders of the open education ecosystem, but it can be argued that these borders could be defined by the shared values. Values and processes represent internal influences on the learning ecosystem conditions.

Several authors have used the concept of infrastructure, when discussing tools and services for open education. Infrastructure refers to fundamental services and facilities that are needed for a certain area to function, for example electrical grid, roads and communication networks. Infrastructure consists of human-made components that are built into the ecosystem. In the case of the open education ecosystem (see Figure 4), the learning utilities form an infrastructure. The digital ecosystem is a wider concept than infrastructure since it emphasizes the socio-technical, self-organizing and crowd-based aspects. Atkins et al. (2007) use the concept of *open participatory learning infrastructure*, which consists of organizational practices, technical infrastructure and social norms. However, they do not go into detail and discuss components of the technical infrastructure. Duval et al. (2011) have used the concept of *open learning infrastructure* for describing the tools and services developed for supporting the complete lifecycle of open educational resources.

The most holistic discussion of the infrastructure for open education is published by Wiley (2015). Wiley proposes four core components for the *open education infrastructure*: (1) open credentials, (2) open assessment, (3) open educational resources, and (4) open competencies. Wiley sees open competencies as the fundamental component, since all other components (OER, assessment tasks, credentials) should be connected to specific competence models. Open education infrastructure would need tools and services that support creating, sharing, reusing, revising and remixing of all four components. In the learning ecosystem model by Chang and Guetl (2007), these would be classified as learning utilities.

In addition looking at the open education ecosystem as a whole, it is also possible to distinguish several smaller ecosystems. A number of authors have discussed the OER ecosystem (Mackintosh, 2012; McAndrew & Farrow, 2013; Yuan, Robertson, Campbell, & Pegler, 2010). Also, open online courses could be seen as independent ecosystems (Pata & Bardone, 2014).

This dissertation is using the concept of *open education ecosystem* to refer to open education as a learning ecosystem. As pointed out by Brown and Adler (2008), ecosystem and infrastructure have different connotations. Infrastructure is often associated with heavyweight predesigned artifacts. Ecosystems, on the other hand, are associated with interaction between the components, loose connections, balance and self-organizing capabilities. Several scholars have used the concept of OEE (Mackintosh, 2012; Meiszner & Papadopoulos, 2012; Lesko, 2013; Schmidt, Geith, Håklev, & Thierstein, 2009). Most of them however have remained at the metaphorical level. Meiszner & Papadopoulos

(2012, p. 1) have defined the open education ecosystem as "the wider socio-technological system that might consist of a number of OEFs and the various resources of such OEFs, including the stakeholders that are populating this ecosystem". This definition refers to open educational frameworks (OEF), which are understood as being organizational frameworks embedded within a technological system. For this dissertation, the open education ecosystem is defined as a learning ecosystem that consists of tools, services, resources and stakeholders who share a common set of values. The core value that defines the extent of the open education ecosystem is openness.

2.4 Design in Context

In the previous section we looked at open education as a digital ecosystem. Complex digital ecosystems consist of a number of tools and services which each have a specific role. These tools and services are used by learning stakeholders who have their personal goals and expectations of the tools they are using. Processes taking place in the open education ecosystem are influenced by various internal and external influences. Designing tools and services for this kind of digital ecosystem is a complex issue that requires a thoughtful approach from the designers. This section will discuss design in the context of digital learning ecosystems.

2.4.1 Design Approach

Design has been divided at various times into different design fields such as architecture, interior design, industrial design, graphic design, fashion design, etc. This dissertation focuses on the design of online learning tools, which is related to several contemporary design fields. The design of any digital artifact requires interaction design. In the case of learning tools, there are some underlying pedagogical ideas that are embedded in the design, and thus it is related to instructional design. A lot of technical decisions and compromises made during the design process are related to software design. Finally, educational systems design should be taken into account in order to understand how the design fits into a larger context.

Interaction design can be considered as the main design discipline for this dissertation, therefore the design approach is explained in the context of interaction design. In a basic sense, interaction design is about defining the structure and behavior of interactive systems. Löwgren and Stolterman (2007, p. 5) define interaction design as a "process that is arranged within existing resource constraints to create, shape, and decide all use-oriented qualities (structural, functional, ethical, and aesthetic) of a digital artifact for one or many clients". This definition points out the broad scope of interaction design. Interaction design is related to a number of a number of academic disciplines (computer science, psychology, ergonomics, social sciences, etc.) and design practices (graphic design, industrial design, service design, etc.).

Nelson and Stolterman (2012, p. 225) argue that design should be seen as a third tradition, a midpoint between the sciences and the arts. Design is related to the applied side of arts (craft) and applied side of sciences (technology). While natural sciences investigate the world as it is, design has an intention of changing the world by introducing human-made artifacts. Löwgren and Stolterman (2007, p. 31) have summarized the essential difference between science and design as follows: “a researcher is interested in reality whereas a designer is interested in what reality could become”. Nelson and Stolterman (2012, p. 41) point out that one of the key characteristics of design is focus on service. Science and arts can be seen as *self-serving* areas where the scientists and artists are driven by their own curiosity and need for self-expression. Design is an *other-serving* field since there is a service relationship with the client.

Design is often discussed from the process perspective (Löwgren & Stolterman, 2007, Chapter 2). The design process takes place in a specific context known as the *design situation*. Two concepts that are related to the design process are the *problem* and the *solution*. The problem refers to how a designer currently understands the design situation. Often, design problems cannot be easily formulated, since they may have incomplete, contradictory, and changing requirements. These kinds of problems are known as *wicked problems* (Rittel & Webber, 1973). The design process is about exploring different possibilities and some authors see the design process as *informed guessing* (Leinonen, 2010, p. 67) The beginning of the design process can be seen as *divergence*, the situation in which the designer is looking in the wider context and considering a number of alternative solutions. In later phases of the design process, the designer has to narrow down the choices and focus on one specific solution or a synthesis of different ideas. This formation of a deeper understanding and more refined design proposal is known as *convergence* (Löwgren & Stolterman, 2007, p. 29–30).

There are a number of process models for interaction design (Brinck, Gergle, & Wood, 2002, p. 16; Cooper, Reimann, & Cronin, 2007, p. 24; Leinonen, Toikkanen, & Silfvast, 2008; Preece, Rogers, & Sharp, 2007, p. 444–463), but these cannot be taken as universal recipes. Each design situation is unique and requires thoughtful thinking to combine the most suitable design methods. Löwgren and Stolterman (2007) see the design of the design process as a vital aspect of design. The design cases included in this dissertation follow the research-based design model proposed by Leinonen et al. (2008). This model is based on four iterative stages: (1) contextual inquiry, (2) participatory design, (3) product design, and (4) the development of software prototype as hypothesis. The software prototype can be seen as hypothesis since it aims to answer the design challenges identified in the earlier phases of research. These four stages of the research-based design provide a general framework for the design process while leaving the designer a freedom to choose appropriate interaction design methods during each stage.

Design can be also seen as a form of communication in which the designer will externalize the design thinking through creating various representations of the designed artifact. Löwgren and Stolterman (2007, p. 28) discuss three basic purposes for creating representations during the design process: forming ideas, communicating with oneself, and communicating with others. Common representations and design artifacts created in interaction design include personas, scenarios, concept maps, user stories, paper prototypes, wireframes, site maps, and various functional prototypes. According to Schön (1991, p. 79), good design process requires reflective conversation with the design situation. This conversation allows the designer to realize consequences of the design decisions and changes in the design situation. Representations and artifacts created during the design process empower the designer to start this reflective conversation with oneself or with others.

One design approach, that emphasizes the active involvement of all stakeholders from the early design process is participatory design (Ehn, 1992). In software development, participatory design approach could be used in various phases. For example, scenario-based design (Carroll, 2000) could be done in a participatory way. The initial scenarios prepared by the designers will be discussed and revised with the stakeholders in the participatory design session. Participatory design approach could be also used with writing user stories and sketching paper prototypes.

When working with people, the designer has to take various roles. Dahlbom and Mathiassen (as cited in Löwgren & Stolterman, 2007, p. 36–37) distinguish between three possible roles for an interaction designer. The *computer expert* offers technical expertise but follows the requirements as specified by the clients and users. The *socio-technical expert* looks not only at the technical solutions, but envisions how the social and organizational factors could be redesigned together with the software design. The *political experts* do not see software design as a neutral activity, but argue that the design should empower a specific group of users. When choosing an appropriate role, the designers have to look not only at the specific project, but also think about their social and ethical responsibilities regarding the wider impact of their design.

2.4.2 Pattern Languages in Design

The previous section discussed that one of the fundamental aspects of design is communication. This communication involves designers and other stakeholders who come from various fields and might not be acquainted with design methods. Therefore, it is argued (Erickson, 2000) that design projects need a common language — *lingua franca* — that is co-created and understood by all the participants involved in the project.

One approach to establishing a common language is to use pattern languages. In the late 1970s, the architect Christopher Alexander and his colleagues developed the original idea of pattern languages (Alexander, 1979; Alexander, Ishikawa, & Silverstein, 1977). According to Alexander, every building and every town is made up of certain recurring entities which he calls patterns. Alexander argues that the use of patterns would support the design of environments that have a quality that is difficult to express in words, a quality that could be called "the quality without a name". The use of a pattern language makes it possible to create an infinite variety of unique buildings and places, just like ordinary language makes it possible to compose an infinite variety of sentences. Alexander composed a network of 253 patterns that describe spaces and buildings at different levels, from regional level (INDEPENDENT REGION) to small things like family pictures and travel souvenirs that make the place alive (THINGS FROM YOUR LIFE)(Alexander et al., 1977). Alexander's patterns are not just descriptions of the spaces and buildings, but they are closely connected to the events that take place in these spaces. Each pattern consists of three parts: description of the *context*, *conflicting forces* and recommended *configuration*. None of the individual patterns are isolated, but each pattern is loosely connected to the smaller patterns it contains and the larger patterns within which it is contained. For example, STREET CAFE belongs to larger patterns of IDENTIFIABLE NEIGHBORHOOD, ACTIVITY NODES and SMALL PUBLIC SQUARES. The street cafe pattern contains a number of smaller patterns, for example OPENING TO THE STREET, A PLACE TO WAIT, DIFFERENT CHAIRS, and a CANVAS ROOF (Alexander et al., 1977, p. 436–439). The power of Alexander's pattern language lies in the fact that the patterns are simple enough to share from person to person. In this way it enables non-architects to participate in the design of their environments.

The idea of dissecting complex solutions into a network of reusable patterns can also be applied in other fields besides architecture. In the 1990s, the design patterns became used in software engineering to describe recurring solutions to common problems in software design (Gamma, Helm, Johnson, & Vlissides, 1994). The pattern languages have attracted interest also in the human-computer interaction community (Dearden & Finlay, 2006; van Welie & van der Veer, 2003). More widely known practical examples of pattern languages are the web design patterns (van Duyne, Landay, & Hong, 2007).

The design patterns approach has also been explored in technology-enhanced learning for more than a decade. Some of the first publications on this topic suggested that patterns could provide a simple and understandable format to capture and share effective learning designs between the practitioners and with the researchers of TEL (Baggetun, Rusman, & Poggi, 2004; Derntl & Motschnig-Pitrik, 2003). Goodyear et al. (2004) discussed the possible pattern language for networked learning and compared it with Alexander's patterns. They suggested the PROGRAMME OF STUDY as the largest independent pattern for networked learning (equal to Alexander's INDEPENDENT REGION pattern). Lower level patterns would include building blocks of courses such as UNIT OF STUDY and MODULE, but also individual pedagogical techniques such as DISCUSSION GROUP or ROLE PLAY. In a later publication, Goodyear (2005) proposed that patterns for networked learning could be divided in three categories: tasks, organizational forms, and learning environment. Rohse and Anderson (2006) see adaptation, self-organization, emergence, and expression of values as key characteristics that make pattern languages valuable for education. Typically, the patterns are written in a way that they must be interpreted and adapted to specific context. The self-organizing aspect of patterns is related to the interdependencies between the patterns. The emergence of new patterns results from the repeated use of good patterns.

Finally, the patterns should not be pedagogically neutral but should carry certain educational values.

An important issue related to pattern languages is the process of identifying design patterns. For Alexander and his colleagues it took years of collaboration to compose their pattern language. In the context of education, Baggetun et al. (2004) suggest combining inductive (from specifics to generalizations) and deductive (from generalizations to specifics) approaches for identifying patterns. Brouns et al. (2005) discuss the possibility of using IMS Learning Design to detect patterns in existing courses. However, this approach would require that the courses are structured in a machine interpretable way. Retalis, Georgiakakis, and Dimitriadis (2007) have suggested a four step approach for identifying design patterns for e-learning systems: an analysis of the functionality offered by the existing systems, developing scenarios for learning activities, comparing how the existing systems support these learning activities, and constructing a pattern language for a specific genre of e-learning systems. This approach can be considered too tool-centered. In the educational context it is important to recognize also these patterns that are not necessary mediated by the use of technology. Gibbons (2014) proposed the most advanced method for identifying patterns in educational context. He argues that any instructional design could be divided to a number of independent layers that influence each other. Gibbons (2014, p. 34) proposed a set of seven layers for common instructional designs: content, strategy, message, control, representation, data management, and media-logic layers. Instructional design patterns should be identified according to layers and taking into account the activities that take place on a certain layer and the influences the layer has on other layers. The order of going through the layers is depending on the context and is not fixed. As an example, Gibbons (2010) analyzed the activity of conversation and identified 77 patterns. Gibbons' approach was considered for this study, but it would have resulted in too large a number of small patterns. Therefore, this study follows Alexander's approach of moving from larger patterns towards smaller patterns.

The use of patterns helps to generalize recommended design decisions in a specific context. Design patterns can be seen as a democratic tool that allows the involvement of various stakeholders in the design process.

2.5 Summary

This chapter outlined the theoretical framework of the dissertation. In order to contextualize this research, I gave an overview of the historical development of technology-enhanced learning and open education. Although open education is commonly associated with open educational resources and MOOCs, there is a wider variety of open approaches to learning. Understanding the main research directions of TEL and different approaches to open education is important for discussing the designed tools in Chapter 4. This dissertation argues that open education could be seen as a digital ecosystem — the *open education ecosystem*. Theoretical underpinnings of digital ecosystems were presented in order to propose the structure of the open education ecosystem in Chapter 6. The final section of the theoretical framework chapter discussed the role of design in the context of this research with special emphasis on pattern languages. A set of design patterns for the open education ecosystem will be presented and discussed in Chapter 6.

3. Methodological Considerations

Combining design practice and research in a methodologically sound way is difficult. One approach to address the challenge is *constructive design research* in which new knowledge is developed through constructing actual design artifacts such as products, systems, spaces or media (Koskinen et al., 2011). This thesis studies the design of online learning tools and the open education ecosystem through designing and constructing five software prototypes. According to Koskinen et al. (2011), constructive design research aims to address limitations of earlier approaches such as user-centered design methodologies. People are often conservative and have difficulties in imagining things that do not exist yet. Therefore, relying only on user studies would result in small improvements rather than in breakthrough ideas. In constructive design research, designers build mockups and prototypes that help people to open up their imagination.

Fallman (2008) has proposed a model of interaction design research that places any design research activity between three interconnected activity areas: *design practice*, *design exploration*, and *design studies*. Fallman illustrates the model as a triangle where each activity area is in one corner (see Figure 5). *Design practice* covers design activities where the interaction design researcher takes a proactive role in the process for designing and developing practical and usable design solutions for a specific context and client. Design practice activities are similar to interaction design activities outside academic research. In design practice, the designed artifact is the primary outcome of the process. The role of research is to support the design decisions. *Design exploration* involves similar interaction design methods to design practice, but has different intentions. It mainly serves the researcher's own research agenda instead of an external client. Design exploration examines the possibilities outside of the current paradigms of use, technology, and economical boundaries. The activity area of *design studies* resembles more traditional fields of academic research. The goal of design studies is to contribute to the body of knowledge about design and to build an intellectual tradition within the field of design research. Unlike the other two activity areas, the focus of design studies is on describing and understanding rather than on creating and changing.

Fallman (2008) argues that an important part of this model is the possibility to move between different activity areas. While the actual methods and techniques used in these activity areas can be quite similar, each area takes a different perspective on design. Fallman uses three concepts to describe the movement within the model: *trajectories*, *loops*, and *dimensions*. Trajectories refer to planned moves or unintentional drifting between two or more activity areas or inside of a single activity area. In the model, trajectories can be drawn as simple lines with an arrow indicating the direction of the movement. Loops describe continuous movements between different activity areas. Dimensions are used to describe tensions between two or three activity areas. They are typically written outside the model. One possible dimension between three activity areas is True—Real—Possible. Design practice deals with what is real, design exploration explores what is possible, and design studies aim to describe what is true.

Fallman's interaction design research triangle provided a methodological framework for the research activities within this doctoral study. In general, this study can be divided into two phases operating in all three areas of activity:

1. *design practice* and *design exploration* on online learning tools;
2. *design studies* on challenges, patterns and structure for the open education ecosystem.

The first phase of the study consisted of five design cases in which online learning tools were designed and constructed. The design cases focused on three different contexts: authoring and sharing platforms for open educational resources, blog-based open online courses, and assessment and recognition of competencies. A more detailed description of the design cases follows in Chapter 5. The aim in the second phase of the study was to make generalizations from the design cases. These generalizations focused on summarizing the design challenges, identifying the design patterns, and analyzing the structure and components of the open education ecosystem.

In Fallman's interaction design research model, the design cases belong to the loop between design practice and design exploration (see Figure 5). OER authoring tool LeMill is closest to the area of design practice, as it was designed with a larger project taking into account the current practices of European teachers. However, the design of LeMill also explored new possibilities related to collaborative authoring and remixing of open educational resources. PILOT and LeContract explored the use of novel pedagogical methods such as progressive inquiry and learning contracts. Thus, these projects could be positioned in the area of design exploration. EduFeedr and DigiMina fall between design practice and design exploration. Both projects were initiated as a result of a practical need, but also explored new ways to support online learning.

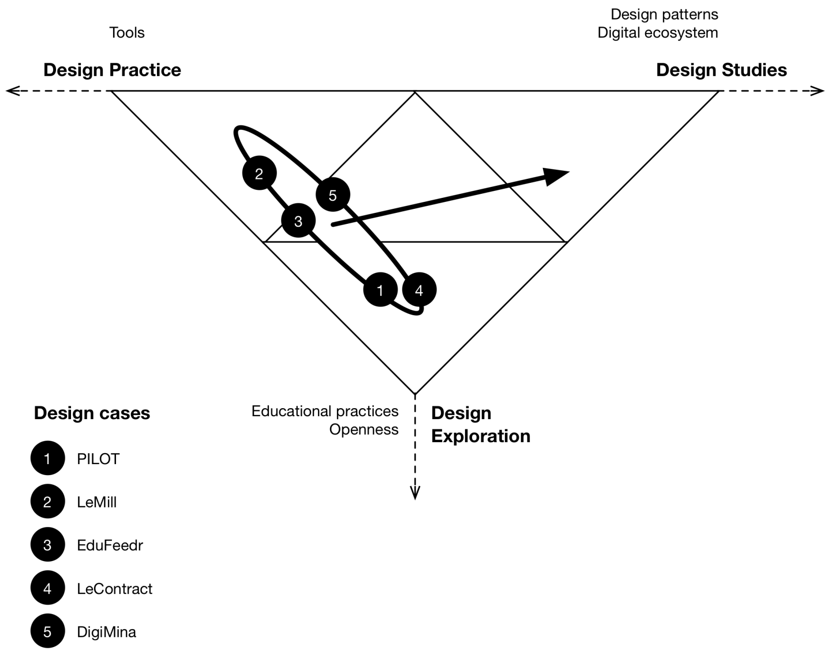


Figure 5. Activity areas of research (based on Fallman, 2008)

In the second phase of the study, the focus of research shifted towards design studies. This move between the activity areas is presented as a trajectory line in Figure 5. In this study, two dimensions can be identified between the activity areas:

- *Tools—Educational practices—Design patterns.* The activity area of design practice covers practical interaction design of online learning tools. The design of tools has to meet both teachers' everyday needs and my personal research interest in changing current educational practices. Challenges relating to new educational practices can be explored through designing prototypes that support these practices. The activity area of design studies aims to provide generalizations that can be applied in designing other online learning tools for a similar context. These generalizations are presented in a form of design patterns.
- *Tools—Digital ecosystem—Openness.* The second dimension of tensions is related to designing online learning tools as part of a digital ecosystem. The activity area of design practice focuses on the interaction design of individual tools. The activity area of design studies, on the other hand, is mainly interested in the relationships and interactions between the tools that form the open education ecosystem. Openness is an important factor both for designing the individual tools and structuring the open education ecosystem. Issues related to openness are examined in the activity area of design exploration.

The following sections discuss the concrete design and research methods used in the two phases of the study in more detail.

3.1 Design Practice and Design Exploration of Online Learning Tools

The first phase of the study involved a number of interaction design methods that were applied in the design cases. As discussed earlier in Section 2.4.1, interaction design can be seen both as a *process* and as a *communication*. The design cases upon which this study is built followed the research-based design model by Leinonen et al. (2008). In fact, LeMill was one of the design cases that contributed to the development of Leinonen's research-based design process model. This model divides the design process into four iterative phases: (1) contextual inquiry, (2) participatory design, (3) product design, and (4) production of software prototype.

The *contextual inquiry* phase aims to define the context and preliminary design challenges. This is done through answering questions such as "who", "what", "why" and "where". The outcomes of the contextual inquiry were documented using the persona method (Cooper et al., 2007). Personas are fictional characters that represent archetypical users of designed tool or service. Personas have a special focus on the goals that these users have related to the designed product. In this study, personas were used internally to build a common understanding of the target group within the design team. An example of a persona is presented in Publication 4.

The *participatory design* phase focuses on defining preliminary concepts. In this study, the scenario-based design method (Carroll, 2000) was used to formulate initial design ideas and to gather feedback from the stakeholders. Scenarios are short stories that describe how users interact with a system in a specific setting to complete their goals. Scenarios are evaluated with stakeholders (who often represent archetypical personas) in participatory design sessions. Scenarios in interaction design have some similarities to use cases in software engineering. Use cases describe alternative ways of reaching the goal, unwanted endings and reactions to possible exceptions (Salinesi, 2004). However, use cases are mainly used for specifying software requirements, while scenarios are used to envision the possibilities. Example scenarios are presented in Publications 1, 3, and 4. Concept mapping method (Novak, 2010) was used to summarize the results of the design sessions and to establish the user interface vocabulary for the next phases of design. Concept maps from the design cases are presented in Sections 5.2, 5.4, and 5.5.

The *product design* phase aims to define use cases, system architecture, and basic interaction with the system. The *user stories* method (Cohn, 2004) is used to document basic functions of the system by describing each software requirement in one or few sentences from the end user perspective. User stories provide textual description of the features but omit the details of the user interface. Paper prototypes (Snyder, 2003) or wireframes (Brown, 2010) were developed to create the preliminary user interface design. In the case of the DigiMina project, flow charts (Brown, 2010) were also created for planning interactions related to the assessment process.

The final phase of Leinonen's research-based design model is the *production of software prototype*, in which the functional prototype is built. Prototypes are potential solutions to the design challenges that were defined earlier in the design process. Functional prototypes were built in four of the design cases. The only exception was the LeContract project that only reached the product design phase.

The exact choice of interaction design methods is always dependent on the design situation. Fallman and Stolterman (2010) see the choice of methods as a consequence of designer's practice and experience. Yee (2010) argues that the "pick and mix" approach, in which established research methods are combined with practice-based methods, has become an established paradigm for design research. The experience from this study shows that the choice of methods is also dependent on the available resources such as team size and the division of roles.

3.2 Design Studies on Challenges, Patterns and Structure of the Open Education Ecosystem

The second phase of the study took a different perspective of the online learning tools and services that were designed. With a shift to the activity area of design studies, the focus changed from individual tools to the open education ecosystem. The general aims of this phase are described in Section 1.3 — understanding the structure of the open education ecosystem and providing research-based insights for designing online learning tools for open education. The research questions that frame this study (see Section 1.5) were reformulated several times during the process, as each new design case provided a better understanding of the context. Generalizations that were made from the design cases include a summary of design challenges (Q1), descriptions of recommended design patterns (Q2), and the structure of the open education ecosystem (Q3).

A multiple case study approach was used to capture new knowledge from the design cases. Yin (2014, p. 16) defines a case study as an empirical inquiry that investigates a contemporary phenomenon in depth and within its real-world context. Case studies can be divided into single and multiple case studies, which may be holistic or embedded. This doctoral research deals with a multiple case study that involves five design cases. All the design cases are holistic, meaning that they do not include several units of analysis within a single case.

The process of content analysis (Berg, 2001) was used to study the design challenges related to open education. In each study reported in the publications, various challenges were recognized. The challenges were categorized into three groups by reconsidering, combining and encoding them (see Section 6.1).

The identification of design patterns combined inductive and deductive approaches, as recommended by Baggetun et al. (2004). The inductive pattern mining approach was used to identify the majority of the design patterns. These were generalizations from the specific instances of how the design challenges were addressed with the implementation of software prototypes or with the design of learning activities. Some patterns were based also on the deductive

pattern mining approach. For example, one of the design patterns was derived from the *lurking* metaphor, which refers to the passive participation in online communities. Two sets of patterns were developed using Alexander's (1979, Chapter 16) approach for constructing pattern languages (see Section 6.2).
Modeling the structure of the open education ecosystem is based on the synthesis of all previous steps in this study. The use of multiple methods for developing the conceptual model of the open education ecosystem can be seen as a methodological triangulation (Cohen, Manion, & Morrison, 2007). The design and development of software prototypes contributed to the understanding of the components of the open education ecosystem and relations between them. Design studies about the design challenges and patterns helped in the conception of the general structure of the open education ecosystem (see Section 6.3).

4. Original Publications

This dissertation is based on five research publications, of which four were published in peer-reviewed journals (Publications 1, 2, 3, and 5) and one in the proceedings of an international conference (Publication 4). The publications are listed and discussed in the order in which the actual design work was started and not in the order of publishing the results. All five publications describe the design process of a different online learning tool for open education. The publiccations included present different phases of the design research. Publications 1 and 4 present the concept and early design phase of two novel online learning tools — *PILOT's* and *LeContract*. Publication 2 discusses an open educational resources authoring tool *LeMill*[23] that is already in use by thousands of teachers. Publications 3 and 5 present both the design process and a small-scale evaluation of *EduFeedr*[24] and *DigiMina*.

This chapter explains the context within which the research was carried out, describes the aims and main contributions of each publication and outlines my own role in both in the design process and in writing the publication. The designed online learning tools itself are discussed in details in Chapter 5.

4.1 Publication 1: Progressive Inquiry Learning Object Templates (PILOT)

Publication 1 presents the concept and discusses the design process of progressive inquiry learning object templates (PILOT's). The original idea of PILOT's emerged in discussions with my supervisor Teemu Leinonen. It is based on our earlier work with the Fle3 learning environment (Leinonen, Kligyte, Toikkanen, Pietarila, & Dean, 2003) and IVA learning management system (Laanpere et al., 2004). The use of these learning environments indicated that teachers and learners had difficulties with setting up authentic and challenging study topics for online discussions. Also, our aim was to alter the situation in which learning objects were used mainly for individual learning (reading, looking, playing, quizzes) or for presentations by teachers. As a solution we proposed a template for creating rich media learning objects that can be used for engaging learners in the collaborative knowledge building processes. The design of PILOT's started initially as a small-scale research experiment that was

[23] http://lemill.net

[24] http://www.edufeedr.net

not part of any officially funded research project. Publication 1 summarizes the outcomes of the initial design and prototyping that was carried out during 2004–2005. The work was later continued in a large-scale European research project called Calibrating eLearning in Schools (CALIBRATE) (2005–2008). My role in this work was to formulate the structure of PILOT's, to design the visual representation and to develop the first rich media prototypes. In later phases during the CALIBRATE project I was responsible for prototyping the authoring interface, writing the design specification for software developers and testing the implementation.

The pedagogical concept of PILOT's is based on the theoretical model of progressive inquiry (Muukkonen et al., 2004). Progressive inquiry is an iterative learning process in which the teacher creates the context, assists learners in setting up research questions, constructing working theories, evaluating their theories critically, and searching for scientific knowledge. This leads to establishing new questions, developing new working theories, and gaining shared expertise. The technical implementation of PILOT's is influenced by the learning objects approach in late 1990s and early 2000s. The publication discusses important issues in teaching with PILOT's, such as the importance of authentic context (Bransford, Sherwood, Hasselbring, Kinzer, & Williams, 1990; Christiansen & Anderson, 2004) in editing and reusing PILOT's.

The main contribution of Publication 1 to this dissertation is that it introduces a number of themes that are present in each of the five design cases and also partly in the publications as well. These themes include social constructivist learning approaches, user generated content and scenario-based design methodology (Carroll, 2000).

In the writing of Publication 1, I was responsible for describing the design and development of PILOT's. Teemu Leinonen assisted me with structuring the paper and formulating the research problems. Sections relating to the pedagogical foundations and research problems were written together by us. The other authors contributed to the design process of PILOT's.

4.2 Publication 2: Information Architecture and Design Solutions Scaffolding Authoring of Open Educational Resources

Publication 2 discusses the design of an online authoring tool for creating and sharing open educational resources. The LeMill tool presented in Publication 2 was designed and developed in a large-scale European research project called Calibrating eLearning in Schools (CALIBRATE) (2005–2008). After the end of the CALIBRATE project we continued the development and dissemination of LeMill within the context of local projects in Finland and in Estonia. In the LeMill project, I played multiple roles. My main responsibility was the user interface and interaction design of the LeMill tool. In order to understand teachers' needs, I run the participatory design sessions with the Estonian teachers and carried out a large number of teacher training workshops in Estonia and in several other countries. Also, I was active in testing the system and documenting the defects.

This publication continues the theme of digital learning resources that was started in Publication 1. Instead of focusing on one very specific type of learning resource, it takes a wider perspective on how digital learning resources could be co-authored and shared online. At that time, the focus of research in technology-enhanced learning was shifting from learning objects to *open educational resources*. Publication 2 studies the question of how a web service design can promote the use and creation of open educational resources. It defines five design challenges that hinder the use of OER's in European schools and presents the design solutions that have been implemented in LeMill to address these challenges. Theoretically, this paper deals with the design methodology (Leinonen et al., 2008), social and legal issues related to the reuse of OER's (Möller, 2007; Schaffert & Geser, 2008), and topics related to learning objects (Friesen, 2004; Parrish, 2004), learning object metadata (Duval & Hodgins, 2004) and interoperability (Nilsson, Johnston, Naeve, & Powell, 2007).

Both, the Publication 2 and the LeMill tool both play an important role in this dissertation. Publication 2 introduces the main theme of the dissertation — *open education*. It also introduces the concept of the *OER ecosystem,* when discussing tools and practices related to use of OER's. The design solutions presented in the paper illustrate the way in which we have relied on the ecosystem thinking that sees the open Web formed from small pieces loosely joined (Weinberger, 2002). Furthermore, Publication 2 introduces the research-based design methodology (Leinonen et al., 2008) that has also been applied in the later design cases.

In the process of writing Publication 2, I contributed mostly to the sections that described the design process and the implementation of design solutions in the LeMill software. I also wrote the section related to the licensing of OER's, created the concept map of LeMill and made minor edits to other sections.

4.3 Publication 3: Design and Evaluation of an Online Tool for Open Learning with Blogs

Publication 3 presents the design and evaluation of an online tool for open learning with blogs. Initial motivation for designing and developing the EduFeedr tool came from an open online course that we organized together with Teemu Leinonen in the spring of 2008 (Leinonen et al., 2009). The aim of the course was to promote the use of open educational resources and LeMill. The course was designed so that each participant used their personal blog to reflect on the course topics. Our experience with using blogs in course context led me to the conclusion that there is a need for a coordination tool that would simplify the management of such courses and monitoring them. In the EduFeedr project, I was the author of the original concept, interaction designer, manager of the project and software tester. The first prototype of EduFeedr was launched in 2010. A number of publications were also written about the initial design and implementation of EduFeedr (Põldoja, 2010; Põldoja &

Laanpere, 2009; Põldoja, Savitski, & Laanpere, 2010). Publication 3 explains the reasoning behind the design decisions and discusses the results of an evaluation study in 10 courses that was carried out in 2013.

Publication 3 provides an overview of some of the recent research on using blogs in online courses (Kim, 2008; Sim & Hew, 2010). It discusses some of the critical issues in blog-based courses such as fragmented discussions, lack of coordination structures, poor support for awareness and the danger of over-scripting. The main aim of the paper is to study how and to what extent can an online tool address these issues. The theoretical basis of these issues lies in the coordination theory (Malone & Crowston, 1994), awareness (Carroll, Neale, Isenhour, Rosson, & McCrickard, 2003) and pedagogical scripting (Dillenbourg, 2002). Publication 3 continues the theme of open education by relating our work to the contemporary discussion about MOOCs (Fini, 2009; Kop et al., 2011; Rodriguez, 2013).

The main contribution of Publication 3 in the dissertation is that it extends the focus of the study from open educational resources to open learning environments. Blog-based learning environments and the wider blogosphere are discussed as examples of digital ecosystems.

I was the main author of Publication 3. My co-authors assisted me with formulating the research questions, planning the evaluation study and discussing the results of the evaluation.

4.4 Publication 4: Externalization of a PLE: Conceptual Design of LeContract

Publication 4 presents the design process and the conceptual design of the LeContract tool, which attempts to support the personal learning contract procedure. The motivation for designing the LeContract tool came from my experiences in teaching open online courses. One of the challenges in these types of courses is to keep learners motivated and goal-oriented. One possible approach to achieve this is to encourage learners to write learning contracts, where they set their personal learning goals, resources and strategies needed to reach the goals, and criteria to evaluate their performance. So far, my colleagues and I have asked learners to use their blogs for writing learning contracts. However, having a special online tool would provide additional opportunities for writing learning contracts and connecting to other learners with similar learning goals. I developed the idea of LeContract in 2010. The initial idea was developed further in our discussions with my colleague Terje Väljataga. I created the personas and scenarios, organized participatory design sessions and developed a set of paper prototypes. However, LeContract is still in the design phase and we have not started with the actual software development.

The pedagogical concept of LeContract is based on the learning contract method (Anderson et al., 1996). The pedagogical and technical implementations are both influenced by the personal learning environments approach (Johnson & Liber, 2008). This approach allows learners to take control of their learning goals and their learning environment (Väljataga & Laanpere, 2010). Technically, LeContract was designed as a piece of social software that allows learners to connect with each other and to form a distributed learning environment (Fiedler & Pata, 2009) in which learning contracts are embedded in learners' PLE's.

The main contribution of Publication 4 for this dissertation is that it addresses some of the pedagogical issues related to open learning environments. Also, it introduces the topic of self-assessment, that is developed further in Publication 5.

As the main author of Publication 4, I was responsible for structuring the paper, reporting the design process and presenting the conceptual design of LeContract. Terje Väljataga wrote the introduction, proposed the structure of the learning contract template and provided some insights into other sections of the paper.

4.5 Publication 5: Web-based self- and peer-assessment of teachers' digital competencies

Publication 5 presents the design and evaluation of a web-based system for assessing teachers' digital competencies. The system called DigiMina (*DigitalMe* in Estonian) was designed and developed in 2011 within the framework of the Estonian national development program for education sciences and teacher education (Eduko). The rapid technological changes in society require that teachers acquire new kind of digital competencies. Our aim in DigiMina project was to develop an assessment framework and to design an online tool that allows teachers' to assess their digital competencies. In the DigiMina project, I was responsible for leading the design and development of the software prototype.

The paper compares a number of frameworks for digital competencies and explains reasons for choosing NETS-T (National Educational Technology Standards for Teachers) framework developed by the International Society for Technology in Education (ISTE)(ISTE, 2008) as the most appropriate for the Estonian context. The assessment framework is based on the previous studies of competency assessment in the clinical context (Miller, 1990) as well as in the educational context (Calvani, Cartelli, Fini, & Ranieri, 2008; Cumming & Maxwell, 1999; Gulikers, Bastiaens, & Kirschner, 2004). The assessment framework developed in Publication 5 is not focused strictly on open education but in technology-enhanced learning in general. However, the design of DigiMina follows the principles of openness and digital ecosystems.

The main contribution of Publication 5 for this dissertation is that it explores how peer-assessment and public competency profiles could make the teachers' professional development more open.

In Publication 5, I wrote the sections on the design methodology, conceptual design, and software implementation of DigiMina. Also, I contributed to the introduction, conclusions, and the validation study. The paper was structured together with co-authors. My co-authors also wrote sections related to teacher's digital competencies and earlier studies on measuring digital competencies.

5. Tools Designed

The previous chapter briefly described the research publications included in this dissertation. Each of the publications is based on the design process of one specific online tool for supporting open education. This chapter will provide more detailed descriptions of the tools designed. Understanding the design of these tools is important for discussing the related design challenges, the role of these tools in the open education ecosystem, and the design patterns that could be identified based on these design cases.

The tools were designed and developed during the years 2004 to 2012. The chronological timeline of design research is presented in Figure 6. During 2004–2007, the main design context was authoring and sharing platforms for open educational resources. Two tools designed during this period were the PILOT learning resource template and the LeMill platform for authoring and sharing open educational resources. The PILOT template was integrated into the LeMill platform. Between 2008 and 2010 the design context expanded from OER to other open educational practices such as open online courses. Two tools were designed during that time: EduFeedr for managing and monitoring blog-based open online courses and LeContract, for supporting the use of the learning contract method. Organizing blog-based open online courses with teachers revealed the differences in teachers' educational technology competency. During 2011–2012, this led to the design and development of the DigiMina platform for assessing teachers' educational technology competencies. After 2012 the focus of research shifted from developing individual tools to studying how the designed tools form a digital ecosystem and identifying recommended design patterns.

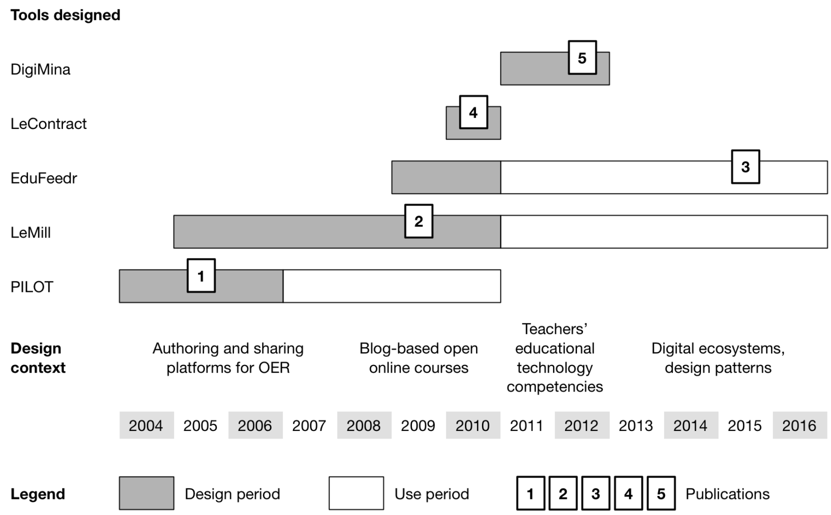


Figure 6. Chronological timeline of design research

The designed tools reached a different level of maturity. Two of the designed tools — LeMill and EduFeedr — gained a wider popularity among the teachers and are still in use. The PILOT template was available for LeMill users between 2006 and 2010. LeContract remained as a design concept that was not developed into actual software product. DigiMina software was developed and evaluated in teacher trainings. For various reasons it was not taken into wider use. Figure 6 also lists the research publications included in this dissertation. Publications are added to the timeline on the years they were submitted and accepted. In some cases the publications do not reflect the final design of the tools as the design process has continued after submitting the publication.

5.1 PILOT

PILOT (Progressive Inquiry Learning Object Template) is a multimedia learning object template for supporting the use of progressive inquiry method. The template is used to create multimedia clip consisting of a number of slides that present the new topic. Each slide in the created multimedia clip has a voiceover recording in which the teacher is explaining the topic and background image that helps learners to visualize the topic, and important keywords that are displayed to anchor new knowledge. The final slide has a list of initial research questions. After watching the PILOT multimedia clip, learners have an initial idea of the topic they are going to study and are able to come up with additional research questions that they are interested in.

The first prototype of PILOT was implemented in 2004 using Macromedia Flash 7. The original idea was that it should be possible to use PILOT as a template that teachers can customize according to their students' needs. However, editing PILOT's with Flash multimedia authoring platform was not a feasible solution for wider use of PILOT's in schools, since Flash is a commercial piece of software and requires a certain level of skill to use. In 2006, it was therefore decided to include PILOT as one of the learning resource authoring templates in LeMill. The structure of the PILOT template is presented in Table 3. Each PILOT has one or more content scenes and a final scene with research questions.

Table 3. Structure of the PILOT template

Element	Scene element	Explanation
Title		Title of the PILOT resource
Short description		Short description of the topic
Full description		Full description of the topic, typically script of the recorded voiceover
Scene		One or more content scenes
	Background image	Background image for the scene
	Voiceover audio	Voiceover audio for the scene
	Keywords	Up to 3 keywords displayed during the scene
Final scene		
	Background image	Background image for the scene
	Voiceover audio	Voiceover audio with research questions
	Research questions	Up to 7 research questions displayed in the final scene and under the PILOT resource

The first version of PILOT authoring template was implemented in the LeMill version 1.1 released in October 2006. It was available until the release of LeMill 3.0 in November 2010. LeMill 3.0 was a major refactoring of the code and the PILOT template was not included due to limited resources. During a period of 4 years, teachers created 32 PILOT learning resources. The progressive inquiry method is especially suitable for subject areas that engage students in an in-depth inquiry. Therefore the most popular subject for PILOT's was biology, but there were also a number of PILOT resources for basic education, special education, and other subjects. An example of PILOT with research questions (in Estonian) is presented in Figure 7[25].

[25] Research questions in Figure 7 are in Estonian. The translation to English is as follows: Which kind of forests have you visited? What is a forest? Why different types of forests grow in particular places? Which layers of plants occur in forests? Which animals live in forests?

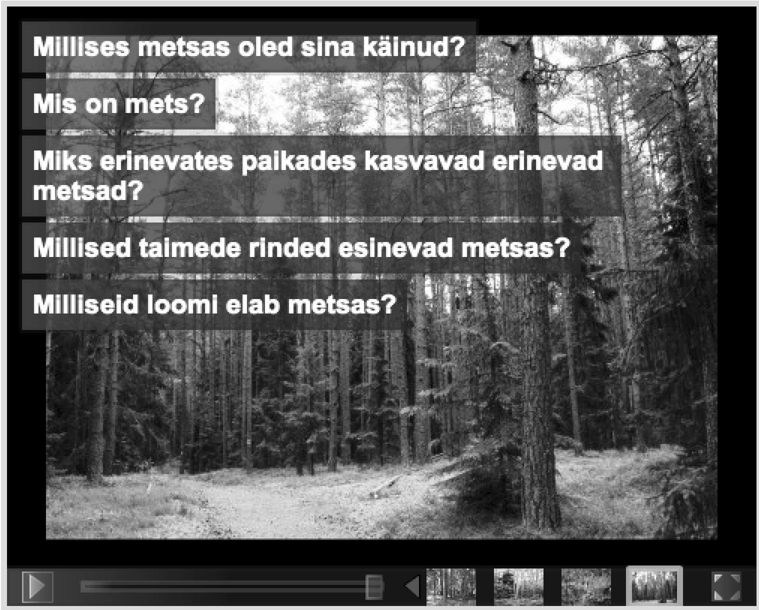


Figure 7. PILOT movie with research questions

The PILOT player includes scroll bar that allows users to scroll to a specific moment in the resource, thumbnail images that link to the beginning of each scene, and a possibility to watch the movie in full screen. The PILOT resources were intended for use in the Fle3 learning environment that had a special discussion area based on the progressive inquiry method. However, feedback from the teachers revealed that in many cases PILOT resources were used in the classroom to introduce a new topic and encourage students' discussions. There are also cases where students were involved in creating PILOT resources. For example, a group of basic school students prepared a play based on "Little Red Riding Hood" by Charles Perrault, took photos of the play, recorded audio clips and compiled the PILOT resource.

5.2 LeMill

LeMill is a software tool and a web community for finding, authoring and sharing open educational resources. The design of LeMill began in fall 2005 and the first prototype was launched in May 2006. At that time, most of the learning object repositories were designed as database systems where teachers could upload learning resources as files or add links to resources in external sites. The design of LeMill was inspired by collaborative authoring platforms such as Wikipedia and social networking services. The aim was to establish a community of teachers who can collaborate on creating and improving learning resources. The design and development of LeMill lasted for a number of years with the last major release being in 2010.

LeMill software was divided into four sections: *content*, *methods*, *tools*, and *community*. The content section provided several templates for creating learning resources, such as *web page*, *presentation*, *exercise*, *lesson plan*, *school project*, and *PILOT*. The purpose of templates is to scaffold the authoring process and achieve consistency between learning resources. In addition to using these templates it was possible to upload *media pieces* (images, sound clips, movie clips, Flash animations) and add *references* to external resources. To enrich the possibilities of LeMill, it was possible to embed external content into web pages and exercises. This allowed teachers to integrate various content such as videos, presentations, quizzes, interactive mind maps and timelines with LeMill resources. In order to enable remixing of content, all the resources created inside LeMill were published under Creative Commons Attribution-ShareAlike license. The front page of the content section is presented in Figure 8.

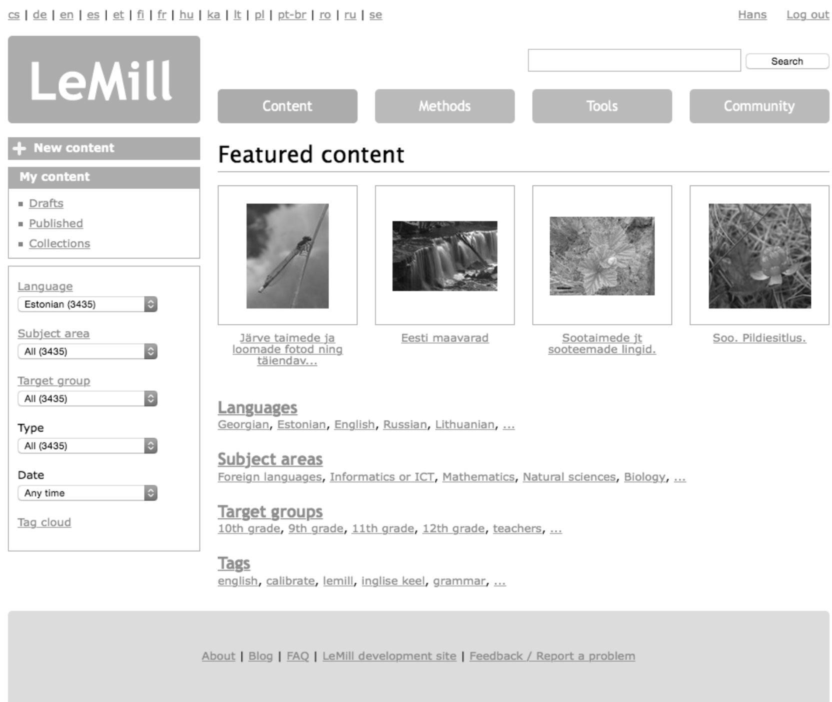


Figure 8. Front page of the content section of LeMill

To emphasize the importance of pedagogical practices with using open educational resources, there were separate sections for descriptions of pedagogical methods and educational tools. Teachers were able to group together related content, methods and tools into *collections*. With the collection, it was also possible to write a *teaching and learning story* that provided pedagogical guidelines and teacher's reflection about using the collection. In the community section, teachers were able to form groups and communicate with their peers. The structure and main concepts of LeMill are presented in Figure 9. Important design decisions behind LeMill are presented as design patterns for collaborative authoring of OER's in Section 6.2.1.

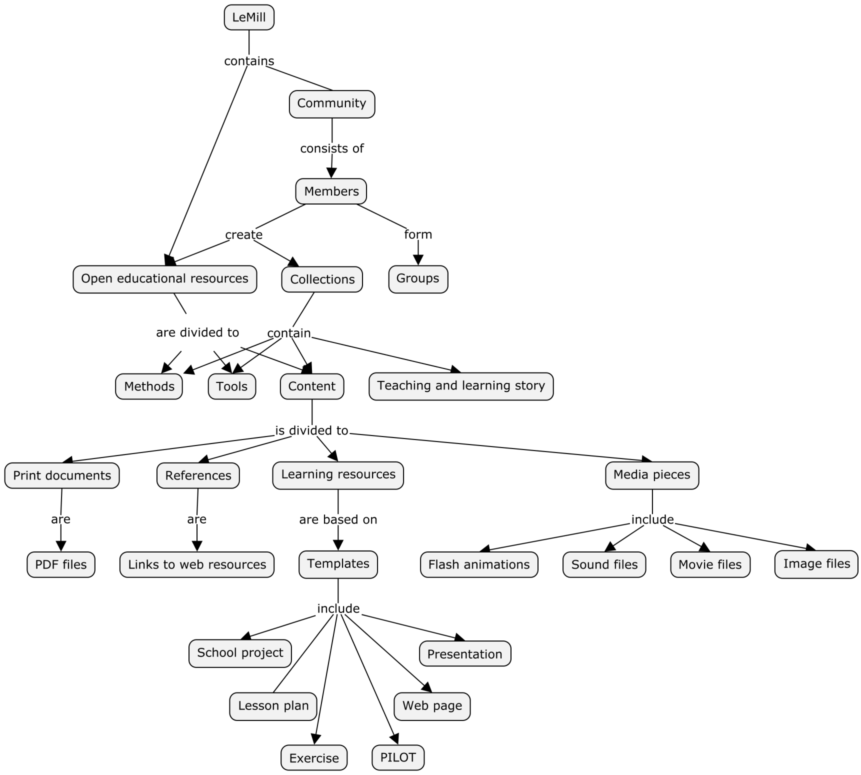


Figure 9. Main concepts of LeMill

LeMill software was translated into 15 languages and used by teachers in a number of countries. At the time of writing, there were 43,000 registered members from 82 countries. All together, they have published 73,000 learning resources in 88 languages. However, the majority of LeMill users are from two countries where it has reached critical mass of members and content. Approximately 70% of LeMill visitors are from Georgia and 15% from Estonia. The remaining 15% is from all other countries.

5.3 EduFeedr

EduFeedr is an online tool for managing and following open online courses where learners use their personal blogs. While the use of blogs has a number of pedagogical benefits (Goktas & Demirel, 2012), blog-based learning environments lack a number of coordination features that are common in learning management systems, such as enrollment in the course and the management of assignments. The distributed nature of blog-based learning environments makes it also more complicated to follow the discussions and be aware of updates. EduFeedr aims to solve these issues.

EduFeedr software was designed and developed mostly during 2009 and 2010, some of the features have been added or improved later. EduFeedr focuses on providing platform for running open online courses. Any EduFeedr user can set up a course by specifying the location of the course blog and important dates (enrollment deadline, beginning and ending date for the course). Learners can enroll to the course by submitting their blog address and e-mail. Since EduFeedr is designed for open online courses, any learner who has a blog on a supported blogging platform can enroll in the courses. Currently, EduFeedr supports two of the most widely used blogging services — WordPress[26] and Blogger[27].

Each course is divided into six sections. *Course feed* page displays the latest blog posts and comments from course blog and learners' blogs. *Course info* page displays general information about the course. *Participants* page displays a list of participants and provides combined RSS (Rich Site Summary) feeds for all course blogs in OPML (Outline Processor Markup Language) format. A logged-in facilitator can also access participants' e-mail addresses and download a list of participants in various formats (vCard for importing into address book, spreadsheet for grading the assignments). In the *assignments* page the facilitator can specify assignments and deadlines. Assignments are published as blog posts in the course blog. Two last sections of EduFeedr display visualizations based on aggregated data. *Progress* page visualizes submitted assignments and *social network* page displays the social network between the learners. Connections mean that a learner has linked or commented another learner. Course feed and progress pages are presented in Figure 10.

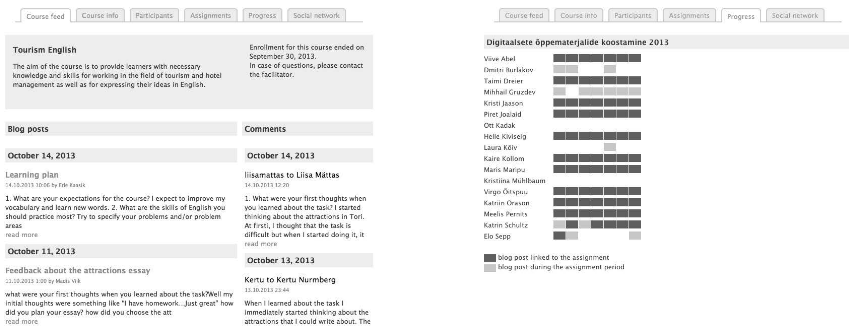


Figure 10. Course feed page (left) and progress page (right) of EduFeedr

EduFeedr has been used in more that 80 courses. Most of the courses have been organized in Estonia, but there are courses also from Spain, Portugal and Finland. Most of the courses are formal higher education courses that are open for external participants. The largest courses have had more than 60 participants, but the average number of participants is 20. All together, EduFeedr has been used by a total of more than 1,700 learners.

[26] https://wordpress.com

[27] https://www.blogger.com

5.4 LeContract

The fourth online learning tool discussed in this study is also designed in the context of open online courses. It is different from other design cases since it remained at the level of contextual design and the actual software prototype was not developed. The tool named LeContract was designed to support the use of the learning contract method in blog-based open online courses. Learners develop learning contracts to specify their personal learning goals, resources they are planning to use, strategy to achieve their goals, and expected outcomes to evaluate their learning. Learning contracts can be revised several times during the study project, based on the guidance from the facilitator and learners' deepened understanding of their learning. At the end of the study project, the leaning contract can be used for writing a personal reflection of the learning process. So far, the author has used blogs for writing learning contracts. However, with blog posts it is not complicated to store different versions of the learning contract and give feedback on the specific parts of the learning contract.

LeContract was designed as an online social networking tool, which enables learners to write *learning contracts* and connect to learners with similar goals. In order to scaffold the process of writing learning contracts, the tool would provide a template for learners. The structure of the default learning contract template is presented in Table 4. Each section in the learning contract has guiding questions that assist the learner in writing their learning contract.

Table 4. Structure of the default learning contract template

Section	Guiding questions
Topic	What is the topic I wish to learn about?
Purpose	What is the purpose of my task? Why do I wish to learn about or learn to do a particular task?
Resources	What kind of technological, material and human resources do I need? How can I get access to these?
Strategy	How do I intend to go about learning this particular topic/task? What action may be involved and in what order will these be carried out?
Outcome evaluation	How will I know when I have completed the task/topic successfully? How shall I judge success?
Reflection	How well did I do? What has worked? What has not worked? Why? What remains to be learnt? What are my strengths and what are my weaknesses? What shall I do next?
Tags	What do I want to learn? My main learning objectives as tags, separated by commas.

LeContract would allow learners to create different versions of the learning contract, thus making it possible to see how learners' goals and strategies have been refined during the study project. Comments given by the facilitator or other learners are attached to the specific version of the learning contract. It is possible to group learning contracts from the same study project by adding them to the *courses*. There are no different user roles for learners and facilitators and any LeContract user could create a course. Furthermore, LeContract would allow the creation of additional *learning contract templates* for specific purposes. The main concepts of the system are presented in Figure 11.

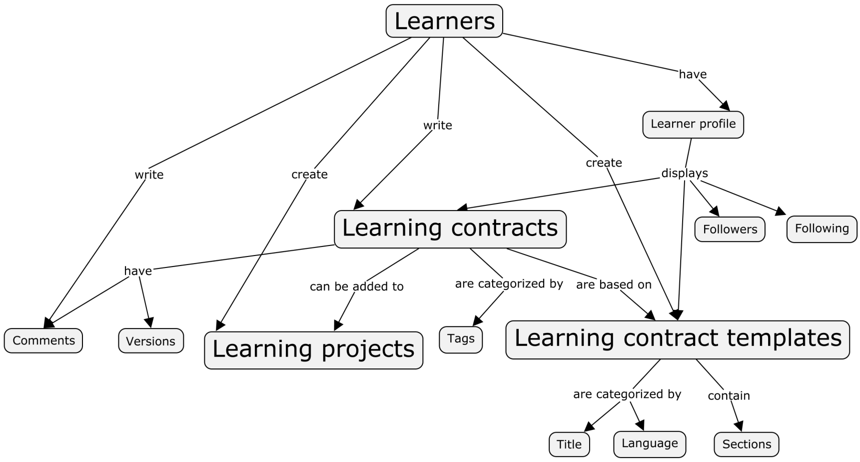


Figure 11. Main concepts of LeContract

The social features of LeContract were designed to include *learner profiles* that show all learning contracts written by the learner and a possibility to follow other learners. Learning contracts are described with tags that make it possible to connect learners with similar learning goals. It was also planned to have a compact view of the learning contract that could be embedded to learners' blog.

The conceptual design of LeContract is documented through various design artifacts. Four personas describe the intended users of the system and their goals. Five scenarios focus on typical use situations such as first experience with LeContract, writing a learning contract, reviewing the learning contracts, creating a new template, and browsing the learning contracts. A more detailed description of the system is in a form of user stories and paper prototypes. The design process of LeContract was carried out in 2010. In recent years there have been several new developments that could influence the design of LeContract. It would be interesting to connect planning one's personal learning with open badges that could be earned for learning activities. Having a large set of learning contracts together with revisions, comments and learners' reflections also opens up various possibilities for learning analytics.

5.5 DigiMina

Blog-based open online courses with teachers revealed that there are important differences in teachers' level of digital competencies. This directed the research towards assessment and recognition of competencies. In 2011 and 2012, the DigiMina tool was designed and developed for web-based assessment of teachers' educational technology competencies. Typically, competencies are assessed using automated computer-based assessment. DigiMina took a different approach by exploring how the assessment process could be made more open by involving teachers through self- and peer-assessment.

The central feature of DigiMina system is a competency test that the users can take. The structure of the competency test depends on the competency model that is used. The educational technology competency model for Estonian teachers was based on ISTE NETS-T framework (ISTE, 2008). This competency model consists of 20 competencies that are divided into 5 groups. Each competency is assessed on a 5-level scale, meaning that there are five assessment tasks for each competency. When taking the competency test, users can estimate their existing competency level and start with an assessment task on that level. Depending on the result, they will be directed to another assessment task on a higher or lower level.

DigiMina supports three types of assessment tasks: (1) automatically assessed self-test items, (2) peer-assessment tasks, and (3) self-reflection tasks. Contextual inquiry indicated that only part of the educational technology competencies could be assessed with automated assessment tasks. Therefore, part of the competencies is assessed through self- and peer-assessment. In case of self-reflection tasks, the users will choose a description of competency level that most appropriately describes their current knowledge and skills. Other DigiMina users who have already completed that specific competency level carry out peer-assessment tasks. Tasks must be created using an external authoring tool that supports IMS Question & Test Interoperability[28] specification.

After completing the competency test for at least one group of competencies, a competency profile will be generated for the user (see Figure 12). Teachers can make their competency profile public and link it to their personal website, social networking profiles or e-portfolio. It is also possible to create groups for teachers from the same school, area or subject. Teachers who are not ready to share their competency profile in public can make it accessible only for members of the same group. Main concepts of the DigiMina system are presented in Figure 13. Although DigiMina was designed in the context of educational technology competencies for Estonian teachers, it could be used also in other settings that have a competency model and a set of assessment tasks.

[28] https://www.imsglobal.org/question/

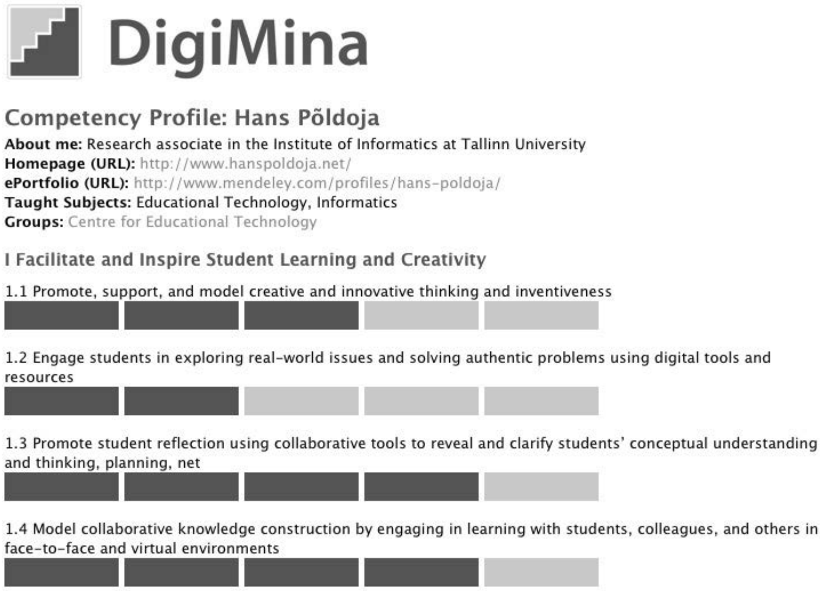


Figure 12. Competency profile page in DigiMina

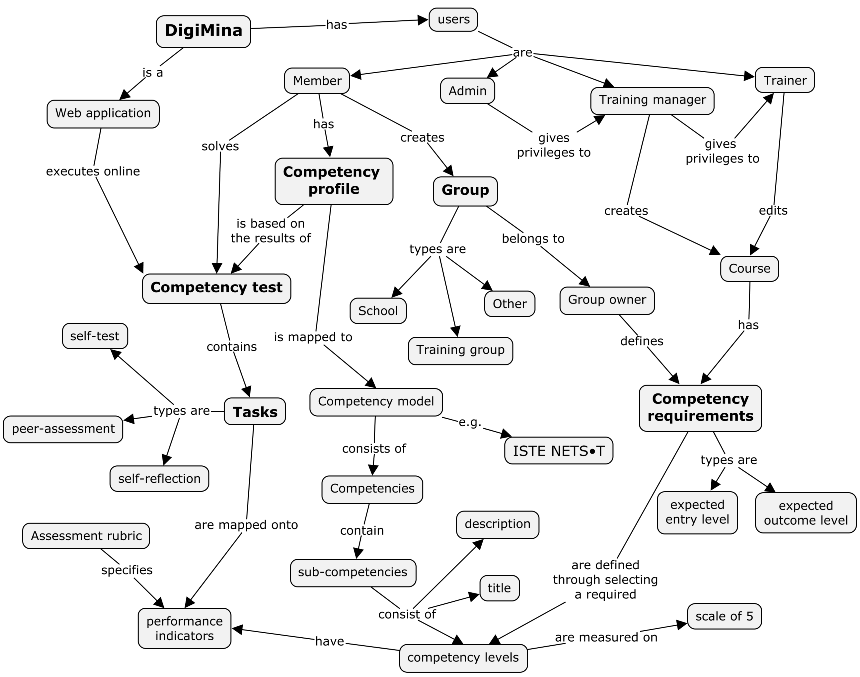


Figure 13. Main concepts of DigiMina

The prototype of DigiMina system was evaluated by a group of 50 teachers. For the evaluation purposes, assessment tasks were prepared for one group of competencies. In general, the teachers who participated the evaluation study were satisfied both with the approach of combining self- and peer-assessment to assessing the educational competencies and with the implementation of the prototype. However, the majority of respondents also believed that teachers would need extrinsic motivation to use such a service (Põldoja, Väljataga, Laanpere, & Tammets, 2014). For a wider adoption at the national level, assessment of educational technology competencies should be integrated into teacher training programs.

6. Results

The tools presented in the previous chapter are practical results of this study. This chapter presents the theoretical outcomes of the study that have been generalized from the design cases. These results respond to the three research questions formulated in Section 1.5. With this study, my aim was to define the main design challenges related to the open education ecosystem (Q1) and to identify and recommend design patterns for addressing these challenges (Q2). Furthermore, I have tried to recognize what kind of structure and components are needed for creating the open education ecosystem (Q3). This chapter is divided into three subchapters that address each of the research questions.

6.1 Design Challenges for the Open Education Ecosystem

The main design challenges related to the open education ecosystem are presented and discussed in three different contexts: open educational resources, blog-based open online courses, and assessment and recognition of competencies. The design challenges are categorized into three groups: pedagogical, socio-cultural, and technical design challenges. It is important to note that design challenges are always dependent on the context within which the design and its results are intended to have an impact. It is not possible to provide a complete and detailed list of design challenges related to the open education ecosystem. The length of such a list would be infinite. Therefore, this dissertation discusses the design challenges that were revealed during this study where the focus has been on open education resources, blog-based open online courses, and assessment and recognition of competencies. These challenges are explained more in depth in the research publications included in this dissertation. In addition to summarizing these, this chapter presents also some additional design challenges that were revealed and generalized in the later phases of the study and thus are not included in the publications. A total of twenty-two (22) design challenges are reported in this dissertation.

6.1.1 Challenges for Open Educational Resources

The context of open educational resources was studied through two online learning tools and services that were designed between 2004 and 2010 — the PILOT learning resource template and the LeMill online community. The main context for both projects was school education in European countries. The design challenges were identified through participatory design sessions with teachers, researchers' observations and literature review. Pedagogical design challenges are related to supporting the use of new pedagogical methods and assuring the quality of open educational resources. Socio-cultural design challenges are related to an assumption that the European teachers do not share their learning resources and do not improve them in a collaborative way. Technical design challenges identified in this study were related to the limitations of existing learning object repositories and challenges related to localization and reuse of learning resources. While a number of new the tools developed in the last decade have addressed many of the technical challenges, it may be argued that the pedagogical and socio-cultural challenges identified in this research remain unchanged.

Pedagogical design challenges

Challenge 1: Digital learning resources are mainly used for individual learning and for presentations
In many cases digital learning resources are used by students for individual learning (reading, looking, playing, quizzes) or by teachers in their classes (presentations). It is a challenge to design OER tools and services that guide teachers away from the acquisition of knowledge paradigm to the participation and knowledge creation paradigms (Paavola et al., 2004).

Challenge 2: Scaffolding the use of new pedagogical methods
Adopting new pedagogical methods might also require new skills from teachers and learners. One specific pedagogical method related to the PILOT project was the progressive inquiry model (Muukkonen et al., 2004). As this model is not well known among the teachers, it was a challenge to design the PILOTs so that they provide pedagogical scaffolding for teachers and learners who are not acquainted with the progressive inquiry.

Challenge 3: Assuring the quality of collaboratively created open educational resources
Collaborative authoring of open educational resources raises issues related to assuring the quality of learning resources. In LeMill, any user may publish a learning resource or edit an existing resource. It requires a critical mass of active users in a certain language and subject area to keep an eye on the quality of learning resources and make necessary changes. One specific area of quality that presents problems is the area of copyright issues related to the use of third party content such as images.

Socio-cultural design challenges

Challenge 4: Lack of collaboration and peer production of learning materials
European teachers are not used to sharing their learning resources with other teachers. Often teachers think that their resources are not good enough for sharing in public. Also, teachers are worried about copyright issues. Some teachers would need external motivation to share their resources. Publishing a

learning resource in the repository is an extra step that is often missed because of lack of time. There is always a threshold for joining an online community and starting to collaborate with other people. Most of the learning object repositories are designed for searching and publishing resources, not for collaboration.

Challenge 5: Lack of reuse, revising and remixing
It is not clear how much the resources from existing learning object repositories are actually reused by the teachers. Teachers who reuse and adapt existing learning resources often do not share their revised versions again with the teacher community. Reusing, revising and remixing of resources are related to copyright. Depending on the license, certain actions may not be permitted or certain resources may not be remixed with each other.

Challenge 6: Multilingualism
In the European Union, there are 24 official languages and a number of semi-official and minority languages. This makes multilingualism a challenge for sharing learning resources throughout Europe. The design of a multilingual learning resource sharing platform should empower smaller language communities within one repository. Providing translation tools may encourage transferring good resources between the languages. Multilingualism also raises challenges related to metadata, because resources may combine multiple languages. It is also important to identify resources that could be reused in different languages without a need for translation (images, simulations, etc.).

Technical design challenges

Challenge 7: Providing localization and reusability while retaining authentic context
Localizing learning resources does not mean simply translating the content from one language to another. It is important that the learning resources provide authentic context for the target group. In the PILOT project, it was a challenge to design a template structure that would allow flexibility in localization, so that the teacher could decide which textual content and media elements should be edited or replaced in the localization process. From the technical perspective, localization is also related to versioning of learning resources.

Challenge 8: Limited findability and poor usability
In the beginning of the LeMill project, limited findability of resources and poor usability of learning resource tools were common issues. Two main options for finding learning resources are using search forms and browsing resources by metadata. Using only search forms limits access to the resources because users can discover only results for their search queries. It is a challenge to design meaningful browsing and recommendation structures based on metadata. Poor usability was an especially critical issue with authoring interfaces. Most of the authoring tools did not emphasize collaboration and social aspects.

Challenge 9: Poor use of the underlying principles of the Web
In mid 2000s, many learning object repositories did not use the underlying principles of the Web, such as openness and “linkedness” to the full extent. In the context of learning object repositories, openness has a wider meaning than open educational resources published under open licenses. Anyone should have the possibility of joining the system, creating new learning resources, and improving existing learning resources. Any resource, collection, and other important view in the system should have a unique and permanent link that can be openly linked to.

6.1.2 Challenges for Blog-based Open Online Courses

Pedagogical design challenges

Challenge 10: Supporting learners with setting up their personal learning goals and strategies
Personal learning contracts allow learners to describe their personal learning objectives, plan the resources and strategies needed to achieve their goals, and set up the evaluation criteria. While the use of personal learning contracts is associated with improving learner motivation (Chyung, 2007), setting up a personal learning contract requires certain scaffolding. Learners would benefit from having a clear structure for the learning contract and access to good examples from other learners.

Challenge 11: Keeping the learner motivation throughout the course
Keeping learners motivated throughout the course is a common challenge in open online courses. Typically, only a part of the learners who sign up for the course actually start participating in the course activities. Open online courses have also a relatively high rate of learners that drop out during the course. This phenomenon has been described as the “funnel of participation” (Clow, 2013). Reinforcing learner motivation is especially complicated when there are little or no face-to-face meetings.

Challenge 12: The danger of over-scripting
The format of blog-based open online courses is more learner-centered than typical online courses, therefore it is critical to find balance between pre-defining the course activities and leaving control to the learners. Too rigid structuring of course activities is known as over-scripting. Over-scripting may disturb natural interactions and problem solving processes, increase learners’ cognitive load, emphasize teacher-controlled learning processes, and impede learners from setting up and achieving their personal learning goals (Dillenbourg, 2002).

Socio-cultural design challenges

Challenge 13: Establishing and keeping the community gravity
The main socio-cultural design challenge related to blog-based open online courses is creating and sustaining the community gravity (Väljataga et al.,

2011). The concept of community gravity was first introduced in the context of social networking sites, where it is used to measure how strongly a user is attracted to a community (Matsuo & Yamamoto, 2009). As with pedagogical challenges, community gravity can be increased both by the design of learning tools and by instructional design.

Technical design challenges

Challenge 14: The fragmentation of discussions in blog-based courses
The structure of conversations in blog-based learning environments is different to that of the typical learning management systems that have a single central discussion area. In blog-based courses, the conversation is fragmented between different blogs. Responses to interesting blog posts may be posted as comments to the original post or as new posts in another blog. It is common that participants visit certain blogs more often than others. Thus, some blog posts and discussions may remain unnoticed. Therefore, there is a need for central aggregation tools that would combine fragmented discussions.

Challenge 15: Lack of coordination structures for managing blog-based courses
Blog-based learning environments lack certain coordination structures that are common in learning management systems. These features include enrollment to the courses, management of assignments, overview of learners' activity, and grading. Lack of these coordination tools increases the facilitator's workload in managing course activities.

Challenge 16: Lack of awareness support mechanisms
Coordination is related to awareness support mechanisms that are typically implemented as notification systems or visualizations. In the context of blog-based courses, there could be notifications of new participants, assignments, blog posts, comments, and trackback links. Various visualizations could increase learners' awareness about their progress in the course and provide comparison with other learners. Awareness mechanisms are also important for facilitators in order to have an overview of the learning process and identify learners who need additional support.

Challenge 17: Commenting and versioning of learning contracts
Currently, the learning contract method is used so that learners publish their learning contract as a blog post in a personal blog. This limits how learning contracts could be elaborated during the course and how others could give feedback to the learning contract. When learners edit their existing learning contract, only the latest saved version of the blog post would be visible. It should be possible to create new versions of learning contracts so that what has been changed and which sections of the learning contract have been edited is clearly visible. Regarding commenting, it would be beneficial to have the ability to add comments to specific sections of the learning contract.

6.1.3 Challenges for Assessment and Recognition of Competencies

The third context examined in this study is assessment and recognition of competencies. During the last decade there have been a number of socio-technical developments that provide new opportunities for enhancing learning, but also require new kinds of digital competencies from the teachers. Competency frameworks such as ISTE NETS-T address these new requirements for teachers' digital competencies but do not provide standardized assessment instruments. Authentic assessment is also related to a specific context. This study was carried out with Estonian teachers. The main design challenges identified in the study are related to defining the performance indicators and test items, opening up the assessment process, and finding a balance between authentic assessment and limitations of computer-based assessment tools.

Pedagogical design challenges

Challenge 18: Defining measurable performance indicators of all the competencies
ISTE NETS-T competency model consists of 5 core competencies which each include 4 detailed sub-competencies. For assessing the level of competencies, there is a need for more detailed performance indicators for each sub-competency. Miller (1990) has proposed four levels for competency assessment: (1) knows, (2) knows how, (3) shows how, and (4) does. With computer-based assessment it is difficult to assess higher level competencies (shows how, does). Therefore, a competency model should include performance indicators on the "knows how" level on assessing applied knowledge for solving problems and making decisions in specific contexts. In the context of the educational technology competency model for Estonian teachers, it was decided to assess each competency on a five-level scale. The resulting assessment rubrics should contain 100 performance indicators (20 sub-competencies, each assessed on 5 levels).

Challenge 19: Defining test items for each performance indicator
For each performance indicator, there must be one or more test items that are presented for the teacher who is assessing his/her educational technology competencies. Depending on the performance indicator, these can either be automatically assessed self-test items, peer-assessment tasks, or self-reflection tasks. For making the assessment process faster, self-test items should be preferred whenever possible. Test items should present real-life problems, be clearly understandable for the teachers, have a reasonable level of complexity, and be situated in an authentic context.

Socio-cultural design challenges

Challenge 20: Encouraging peer-assessment
The possibilities of automated computer-based assessment are limited to certain types of tasks. Assessing higher-level competencies would require human feedback. It is a challenge to design a system that would motivate people to

give feedback to their peers. Related to this, it is important to guarantee the quality of peer-assessment by requiring a certain level of competency from the reviewers and involving multiple reviewers for each peer-assessment tasks.

Challenge 21: Making the competency data open
The level of ones' skills and competencies is traditionally considered sensitive information that is kept private. Sharing competency profiles inside a small group (e.g. teachers from the same school) could open up possibilities for peer learning. Expert teachers could make their competency profiles open for a wider audience. Having open but anonymous competency data at the national level would provide various opportunities for making policy level decisions, planning teacher trainings, and performing learning analytics. It is a challenge to design a system in which people could see the benefit of sharing their competency information.

Technical design challenges

Challenge 22: Combining authentic assessment with limitations of online assessment tools
Authentic assessment tasks should be implemented within the limitations of online assessment tools. Gulikers et al. (2004) have proposed five aspects for enhancing the authenticity of assessment: assessment tasks, physical context, social context, form of assessment, and assessment criteria. The design of assessment tasks and assessment criteria is directly dependent on the limitations of the assessment tool. Online assessment tools could accentuate the social context by providing some collaborative features. The form of assessment could be made more authentic by including videos and simulations. The authenticity of the physical context cannot be influenced directly by the design of assessment tools.

6.1.4 Summarizing the Design Challenges

This section described 22 design challenges that were identified in five design projects. Due to the focus of the projects, the design challenges were grouped under three different contexts: collaborative authoring of OER's, blog-based open online courses, and assessment and recognition of competencies. Furthermore, the design challenges were classified as pedagogical, socio-cultural, or technical. The next section provides an overview of how these design challenges have been addressed. In the following text, design challenges are referred to with numbers C1–C22.

6.2 Design Patterns for the Open Education Ecosystem

Solutions to the design challenges discussed earlier are presented in a form of design patterns. It was decided to identify design patterns separately in two contexts — collaborative authoring of open educational resources and blog-based open online courses. In both contexts, two of the designed tools (LeMill and EduFeedr) were used for several years with a large number of people. This allowed observation of how the design solutions work in real life and the process of making necessary changes to the design. Real life use also highlighted how the designed tools are related to other tools and services that are used in the same contexts. This allowed the identification of design patterns that position design solutions developed in this study into a larger open education ecosystem. It may be considered that the third context — assessment and recognition of open competencies — is still emerging. Solutions such as open badges are not yet widely used in education. Therefore, it was decided not to propose a connected set of patterns for this context.

6.2.1 Collaborative Authoring of Open Educational Resources

A set of 12 design patterns is identified for collaborative authoring of OER's. Figure 14 presents a pattern network that shows connections between the patterns. Alexander (1979, p. 314) gave inspiration to this visualization of patterns.

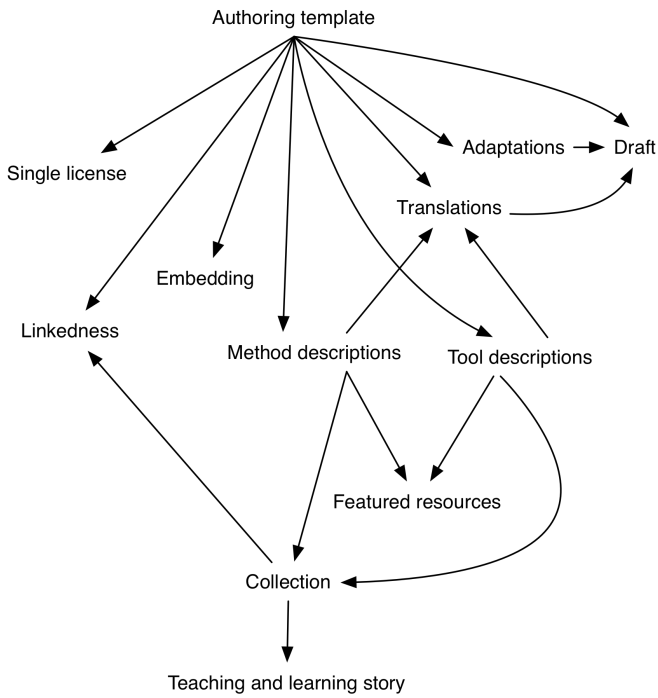


Figure 14. Pattern network for collaborative authoring of OER's

A central pattern in this network is the AUTHORING TEMPLATE (1). Other larger patterns that contain other patterns are METHOD DESCRIPTIONS (8), TOOL DESCRIPTIONS (9), COLLECTION (10), and TRANSLATIONS (6). There are certain similarities between the main concepts of the LeMill system (see Figure 9) and the identified design patterns. However, some of the main concepts of LeMill were too generic for developing into design patterns (e.g.

learning resource). Also it was decided to focus only on these design patterns that are specific for collaborative authoring of OER's. This study does not discuss social software design patterns that are common for various online platforms (user profile, dashboard, groups, tagging, etc.).

In pattern descriptions, I follow the format used by Alexander et al. (1977). Each pattern starts with a short description of the context that specifies larger patterns connected to this pattern. This is followed by a discussion of conflicting forces and description of the recommended configuration. Finally, other connected patterns are referred to. As this study has identified design challenges, each pattern also refers to the addressed design challenges.

Design Patterns

Pattern 1: Authoring template
This pattern deals with providing a clear structure for creating new learning resources.

It may be difficult to start creating a new learning resource from the scratch. Having a certain predefined structure for new learning resources would help teachers to get started. A large collection of peer produced learning resources would benefit from having a consistent structure and layout. Consistent structure contributes to the quality of learning resources. On the other hand, it is important to achieve balance between predefined structure and flexibility for the authors.

Therefore: The learning resource authoring tool should provide a set of pedagogical templates that scaffold teachers and content producers in creating new resources. LeMill provided six pedagogical templates for creating learning resources: web page, presentation, exercise, lesson plan, school project, and PILOT. Web page is a generic template while other templates provide a more predefined structure. Authoring templates consist of different types of sections that are called blocks in LeMill. For example, web pages in LeMill consist of text blocks, media pieces and embed blocks. The exercise template has additional blocks for various question types. Templates may also scaffold the use of new pedagogical methods, such as the PILOT template in LeMill.

This is a central design pattern, that is related to a number of smaller design patterns. Learning resources based on authoring templates have a DRAFT (2) status, support EMBEDDING (3) and LINKEDNESS (4), are published under a SINGLE LICENSE (5), and could be developed into TRANSLATIONS (6) or ADAPTATIONS (7). Two special types of authoring templates are METHOD DESCRIPTIONS (8) and TOOL DESCRIPTIONS (9). As a central design pattern, authoring template is addressing a number of design challenges: (C3) assuring the quality of collaboratively created open educational resources; (C4) lack of collaboration and peer production of learning materials, (C5) lack of reuse, revising and remixing, and (C2) scaffolding the use of new pedagogical methods.

Pattern 2: Draft

This pattern deals with distinguishing resources that are under development from resources that are completed. Draft status is an attribute of certain AUTHORING TEMPLATES (1).

When a learning resource is developed using an open online platform, each saved version of the resources is accessible. It means that anybody may find resources that are under development. On one hand it is good, since people will see which new resources are currently under development. On the other hand, finding incomplete resources might be confusing. Therefore it is important to make a clear distinction between resources that have been completed and resources that are under development. Also, some authors are not comfortable with showing their incomplete works.

Therefore: Incomplete resources should be clearly distinguished from complete resources. In LeMill, this separation is implemented as a draft status. All draft resources have a default cover image that shows the type of the resources (web page, exercise, lesson plan, etc.). Draft resources can be either public or private. Author names are not displayed on the resource page when the resource is in draft status. However, the information about authors can be accessed from the editing history. When the resource is ready for publishing, the first author can publish the resource. During the publishing process the author must choose or add a cover image for the resource. Published resources can be easily distinguished from draft resources by having a cover image. Also, author names are displayed with published resources. In search results, draft resources are displayed only after published resources.

Draft status is addressing two design challenges: (C3) assuring the quality of collaboratively created open educational resources and (C4) lack of collaboration and peer production of learning materials.

Pattern 3: Embedding

This pattern deals with using external media content in learning resources. Embedding supported in some AUTHORING TEMPLATES (1).

It is often not feasible for a learning resource authoring tool to provide a large feature set and to support a wide variety of content types. It is common that web sites focus on a specific type of content, e.g. YouTube focuses on movies and SlideShare on presentations. In many cases these web sites provide an embedding code that allows the reuse of their content on other web pages. From the authors' perspective, there is a need to use a media content to enrich their learning resources. In case the content is under copyright, they cannot copy the actual content to their resource, but can use an embedded player that plays the content from the original location.

Therefore: Limitations of the authoring tool can be addressed by enabling users to embed external content from other online systems that provide an embedding code. Examples of content that could be embedded include movie clips, audio clips, presentations, maps, mind maps, interactive timelines, quizzes, simulations, simple educational games and other types of resources. Good examples of authoring tools that rely on embedding are blogging platforms

WordPress and Blogger. LeMill allows embedding of external resources on the *web page* and *exercise* templates.

Embedding is addressing two design challenges: (C5) lack of reuse, revising and remixing, and (C9) poor use of the underlying principles of the Web.

Pattern 4: Linkedness

This pattern deals with making hypermedia connections between the resources. Linkedness is supported by AUTHORING TEMPLATES (1) and COLLECTIONS (10).

Many learning resources in traditional learning object repositories have to be downloaded for viewing and using (text documents, presentations, etc.). Also, some repositories restrict access to resources only to logged in members. LeMill took a different approach and limited its focus on web-based learning resources that are openly accessible and can be viewed and edited using a standard web browser. One of the main benefits of web-based resources is that they can be linked with each other. Search engines follow links between the resources and highly linked resources are more visible in search results.

Therefore: Learning resource authoring platform should focus on web-based learning resources that are highly interlinked. Resources should be openly accessible to anybody and have a permanent location that can be linked to from any other web page. The design of the platform and community guidelines should encourage internal linking between the resources, so that there are no dead-end resources. Some of the interlinking can be achieved automatically. For example, authors' name should link to a profile page, metadata fields such as a subject area should link to a browsing page showing other resources from that subject, etc. The authors should create other internal links such as links to related resources manually.

This pattern addresses the limited findability (C4) and poor use of the underlying principles of the Web (C9).

Pattern 5: Single license

This pattern deals with legal issues related to combining learning resources with each other. License is attached to all resources based on AUTHORING TEMPLATES (1).

There are six different Creative Commons licenses and a number of other open content licenses that could be used for open educational resources. It is important to understand that when creating adaptations, not all works under Creative Commons licenses could be combined with each other. The most liberal license is Creative Commons Attribution license. Works under this license may be combined with works under any other Creative Commons license when creating adaptations. Works under Attribution and Attribution-ShareAlike licenses are considered Free Cultural Works. Licenses that have Non-Commercial or NoDerivatives restriction are considered non-free licenses. If users are free to choose any of the six licenses for their works, it will result in separate pools of content that cannot be combined with each other when creating adaptations.

Therefore: Use a single license for all works created on the same authoring platform. This allows users to combine different works into adaptations. The choice of license is dependent on the requirements, but licenses acknowledged as Free Cultural Works are preferred. LeMill uses Creative Commons Attribution-ShareAlike license for all learning resources created inside LeMill. The same license is also used in Wikipedia.

This pattern addresses the lack of reuse, revising and remixing (C5).

Pattern 6: Translations

This pattern deals with translating learning resources based on AUTHORING TEMPLATES (1) from one language to another.

In the European context, multilingualism is an important design consideration. Learning resource sharing platforms should be designed so that they support transfer of resources between different language communities. This process should not be seen as a mere translation of resources, but localization and adaption to another socio-cultural context. It is possible to allow a single translation in each language or multiple translations that supplement each other. In order to keep the focus of the community, it was decided to allow a single translation into each language in LeMill. One of the issues that became evident with translations was a large number of incomplete translations. Often people started the translation process without completing the translation.

Therefore: Learning resource authoring tool should provide the ability to translate existing learning resources into another language. When starting a new translation, users should be able to specify the language of the translation. Original text should be displayed next to the translation form. If a resource is divided into separate sections, it should be possible to translate each section separately. Partial translations should be initially saved in DRAFT (2) mode to distinguish them from completed translations. Translated versions should be linked to the original resources.

Translations are related to the DRAFT (2) pattern and address two design challenges: (C6) multilingualism and (C7) providing localization and reusability while retaining authentic context.

Pattern 7: Adaptations

This pattern deals with adapting learning resources based on AUTHORING TEMPLATES (1) to a specific target group and learning context.

Adaptation of learning resources is related to the five 'R's of openness (Wiley, 2014) discussed earlier in Section 2.2.2. These involve revising and remixing of resources. Teachers should be able to revise learning resources according to their learners' needs and specific context. Also, it should be possible to combine several resources through remixing. Providing a flexible way for making adaptations is a challenging task. Wiki-based online collaboration platforms such as Wikipedia allow members to edit and improve a single instance of the resource. Learning resources are different from encyclopedia articles — there could be several alternative learning resources in the same topic. A challenge with adaptations is that people would too easily create revised versions that have very little differences with the original resource. On the other hand, it is also possible, that the adaptations could become improved or significantly different from the original version.

Therefore: Learning resource authoring platform should provide the ability to create adaptations (revised or remixed versions of the original resource). New adaptations are initially in DRAFT (2) status. Adaptations should be linked to the original resource. Original versions and significantly improved adaptations should be displayed in a more prominent position than adaptations with minor changes. In LeMill, users editing the resource are required to identify whether they performed a major or minor edit.

Adaptations are related to the DRAFT (2) pattern and the design challenge regarding the lack of reuse, revising and remixing (C5).

Pattern 8: Method descriptions

This patterns deals with sharing descriptions of pedagogical methods using a simple AUTHORING TEMPLATE (1).

Teachers are not only looking for resources that could be used with students, but also for good ideas regarding innovative learning activities, educational practices and other pedagogical methods. Methods should be seen as generic descriptions of activities that could be reused in different contexts.

Therefore: The learning resource authoring platform should provide tools for describing and sharing descriptions of pedagogical methods. To emphasize the importance of methods, LeMill included a separate section for method descriptions. Adding method descriptions was made a straightforward process by having a simple template for the textual description of the method. Similar to learning resources, it was possible to create TRANSLATIONS (6) of method descriptions.

Method descriptions are related to a number of smaller patterns. They can be developed into TRANSLATIONS (6), added into COLLECTIONS (10), and displayed under FEATURED RESOURCES (12). This pattern addresses two design challenges: (C1) digital learning resources are mainly used for individual learning and for presentations and (C2) scaffolding the use of new pedagogical methods.

Pattern 9: Tool descriptions

This pattern deals with a simple AUTHORING TEMPLATE (1) for sharing descriptions of tools that could be used for teaching and learning.

Teachers use various digital and non-digital tools in their lessons, for creating learning resources and for communicating with other teachers, students and parents. Learning resource platform would benefit from sharing descriptions of these tools.

Therefore: The learning resource authoring platform should enable the sharing of descriptions of educational tools. Tools could be seen as a third important component in addition to learning resources and methods, therefore LeMill had a separate section for tool descriptions. Similar to methods, tool descriptions were based on a simple template that had a textual description and location of the tool. Also, it was possible to translate tool descriptions to other languages.

Tool descriptions can be developed into TRANSLATIONS (6), added into COLLECTIONS (10), and displayed under FEATURED RESOURCES (12). This pattern addresses the challenge that digital learning resources are mainly used for individual learning and for presentations (C1).

Pattern 10: Collection
This pattern deals with presenting related resources in context. Collections may contain learning resources, METHOD DESCRIPTIONS (8) and TOOL DESCRIPTIONS (9).

There is a need for a simple way to combine and present related resources in context. In the simplest case, teachers could group together learning resources, tools and methods used in one lesson or one study project. Collections could be also used for presenting resources dealing with the same topic as well as resources created in the same teacher training or otherwise related resources. Collections could enhance the findability of resources and highlight high quality content.

Therefore: The learning resource platform should enable users to create collections. Users should be able to add to collections both their own resources and resources created by others. It should be possible to rearrange the order of resources added to a collection. In LeMill, the content, method descriptions and tool descriptions are grouped together in a collection. It is also possible to add other collections into a single collection. This is useful for creating a course collection and separate collections for each lesson. All collections are public.

Collections support LINKEDNESS (4) of resources and can be described with a TEACHING AND LEARNING STORY (11). This pattern addresses the following design challenges: (C2) scaffolding the use of new pedagogical methods, (C5) lack of reuse, revising and remixing, and (C8) limited findability and poor usability.

Pattern 11: Teaching and learning story
This pattern deals with sharing experiences from using a COLLECTION (10) of resources in the learning process.

In order to share best practices from using learning resources, teachers and learners should be able to document their experiences. One approach is to add comments to specific resources. Although LeMill had a commenting page for each resource, this feature was not widely used. Another approach is to add reflection to a collection of related resources. This would provide a more contextual way of sharing experiences.

Therefore: The learning resource platform should enable users to reflect on their experience from using learning resources. In LeMill, it was decided to connect these reflections to collections. The author of the collection can write a "teaching and learning story" that describes her experiences from using a collection of related content, method and tools in the actual learning setting. It is possible to have only one teaching and learning story for each collection. The story could be edited over time, if the teacher has additional tips to share. Collections with teaching and learning stories should be presented so that users will easily notice them.

This pattern addresses two design challenges: (C1) digital learning resources are used mainly for individual learning and for presentations and (C2) scaffolding the use of new pedagogical methods.

Pattern 12: Featured resources

This pattern deals with highlighting good learning resources, METHOD DESCRIPTIONS (8) and TOOL DESCRIPTIONS (9).

Making good resources easily findable is a challenge for learning resource sharing platforms that have a large number of resources. To address this challenge, one approach is to display featured resources that are recommended for users. These recommendations could be either manually selected by the editors of the platform or automatically selected based on learning analytics (number of times the resource has been marked as a favorite, added to collection, translated to another language, etc.). In LeMill, learning analytics was preferred since the managers of the portal only understood some of the languages used. Depending on the amount of high quality resources, it should be decided how personalized the featured content is. For example, it is possible to personalize the displayed items based on users' language, subject areas or location.

Therefore: The learning resource platform should highlight high quality resources. In LeMill, this is implemented as featured resources. The front page of LeMill always displays a collection that has a teaching and learning story. Front pages of the content, methods and tools section display three featured content items, method descriptions or tool descriptions. The front page of the community section highlights three active members of LeMill. The language of the displayed resources is dependent on the user interface language that is used for browsing LeMill.

This pattern addresses three design challenges: (C8) limited findability and poor usability, (C5) lack of reuse, revising and remixing, and (C3) assuring the quality of collaboratively created open educational resources.

Summary

All of the previously described design patterns were identified by studying the implementation of the LeMill tool. The only pattern that eventually became problematic in actual use was ADAPTATIONS (7). It was implemented in a way that allowed authors to lock their resource so that other people were only able to edit copies of the resource. This resulted in a number of very similar copies. Therefore it was decided to remove this feature from LeMill. However, creating adapted versions is an important feature that should be carefully considered for the learning resource authoring platform.

These 12 patterns addressed all of the design challenges related to collaborative authoring of OER's. The mapping of design challenges and design patterns is presented in Figure 15.

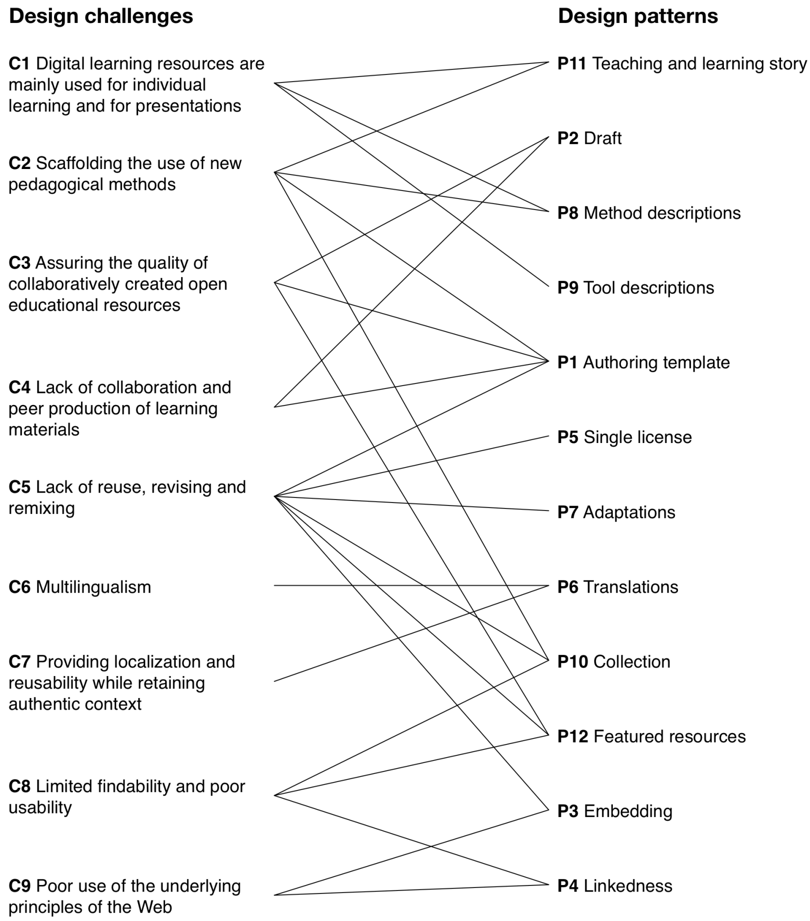


Figure 15. Mapping of design challenges and patterns for collaborative authoring of OER's

As can be seen from Figure 15, certain design challenges have been addressed more thoroughly than others in this study. These central design challenges include (C5) lack of reuse, revising and remixing, and (C2) scaffolding the use of new pedagogical methods. Most of the design challenges are related to two or three patterns, while two design challenges are only addressed by the TRANSLATIONS (6) pattern.

These patterns can also be discussed from the digital ecosystems perspective. Open educational resources can be seen as a niche in the open education ecosystem. In natural ecosystems, populations form niches in the microhabitats in which they live. The OER niche consists of learning utilities (OER tools and OER's) and learning stakeholders. In a more narrow perspective, it is also possible to refer to the OER ecosystem as a stand-alone digital ecosystem. However, OER tools are connected to other parts of the open education ecosystem and the same learning stakeholders could also be active in other niches of the open education ecosystem.

As discussed earlier in Section 2.3.1, the essential characteristics of digital ecosystems are interaction and engagement, balance, clustered and loosely coupled relationships, and self-organization between the species (Chang & West, 2006). These characteristics are all present in the patterns presented in this chapter. AUTHORING TEMPLATES (1) frame the interaction possibilities between the learning stakeholders who create OER's. Interaction with other OER tools and online platforms is achieved through EMBEDDING (3) and LINKEDNESS (4). Patterns that contribute to achieving balance include DRAFT (2) status for incomplete resources and a SINGLE LICENSE (5) that enables remixing of content within one authoring platform and between other online communities using the same license. Loosely coupled open educational resources can be connected through COLLECTIONS (10) and LINKEDNESS (4). OER authoring platforms also needs a certain level of self-organization. For example, FEATURED RESOURCES (12) are based on learning analytics data and users organize the resources into COLLECTIONS (10). Self-organization is also needed for using features such as ADAPTATIONS (7) in a way that benefits the development of the ecosystem.

In a similar way, other niches of the open education ecosystem could be described through design patterns and discussed as a digital ecosystem. The following section presents a network of design patterns for blog-based open online courses.

6.2.2 Blog-based Open Online Courses

Studying the solutions for coordinating blog-based open online courses also resulted in 12 design patterns. The pattern network that shows the relationships between the patterns is presented in Figure 16.

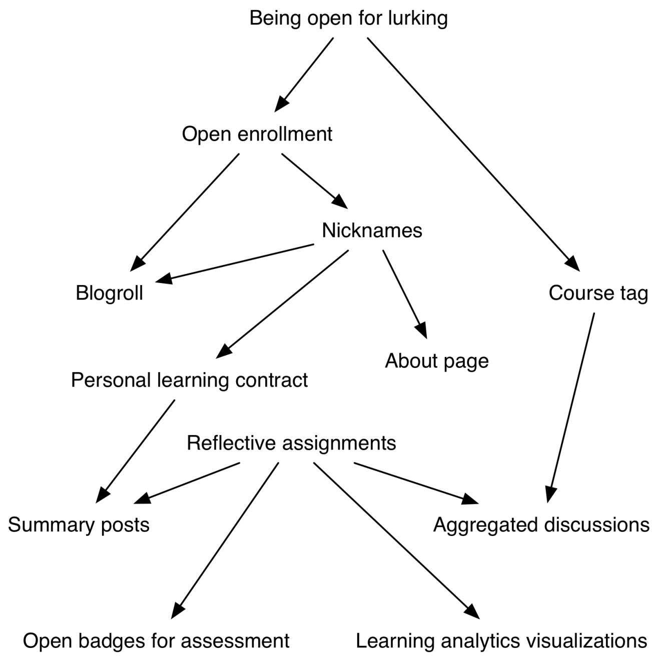


Figure 16. Pattern network for blog-based open online courses

In this context, the design patterns describe not only software implementations but also pedagogical approaches for addressing the identified design challenges. Two central patterns of this network are BEING OPEN FOR LURKING (13) and REFLECTIVE ASSIGNMENTS (21). While the former emphasizes the open nature of the courses, the latter describes main learning activities. Other larger patterns include OPEN ENROLLMENT (14), NICKNAMES (15), and PERSONAL LEARNING CONTRACT (17). Brief descriptions of the patterns are provided in the following section.

Design Patterns

Pattern 13: Being open for lurking
This pattern describes the open nature of blog-based online courses.

Online courses that take place in traditional learning management systems are typically accessible only for enrolled students. Also, many xMOOCs require learners to enroll to the course to see learning resources and course discussions. This limits learners access to the course, makes it more difficult to decide if the course would comply with their learning goals, and artificially raises the number of enrolled students. Having the ability to observe the learning activities would also be helpful to other teachers who could use experiences from open online courses as an initiative to improve their own courses.

Therefore: Open online courses should enable anyone to observe course discussions and access learning resources without enrolling to the course or logging in to the learning environment. In Internet culture, lurking is a common way of participating in online forums and other communities.

This is a central design pattern that is related to smaller patterns such as OPEN ENROLLMENT (14) and COURSE TAG (19) that is used in various online platforms. Being open for lurking is a general characteristic of open online courses that is not directly related to any of the specific design challenges.

Pattern 14: Open enrollment
This pattern deals with enrollment in the courses. It is related to the possibility of BEING OPEN FOR LURKING (13).

Blog-based open learning environments require a central coordination platform for managing enrollment to the course. In a simple case, people interested in participating the course could add their blog addresses to a wiki page. However, this requires a lot of manual work for subscribing to participant blogs. In many cases blog-based open online courses are run as extensions of formal higher education courses. It is possible, that too large number of informal participants would make it difficult to follow and support learners. It is important to find balance between massive openness and a functional learning community.

Therefore: Coordination platforms for blog-based open online courses should enable open enrollment. The facilitator of the course should be able to specify how long the course is open for enrollments. In a more advanced case, the coordination platform might also distinguish between different types of enrollments (formal participants, informal participants).

Open enrollment is related to two smaller patterns: learners should be able to use NICKNAMES (15) and the list of enrolled participants should be able to be copied as a BLOGROLL (18). This pattern addresses the lack of coordination structures for managing blog-based courses (C15).

Pattern 15: Nicknames
This pattern deals with privacy issues related to blog-based open online courses. The use of nicknames is part of OPEN ENROLLMENT (14).

In blog-based learning environments, anyone can read the discussions that take place in blogs. Typically learners write under their own name and blog posts written during the course become part of their online identity. However, this is not suitable for discussing sensitive topics. Also, some students do not want their learning process to be found with search engines. One option for these problems is to protect blog posts with a password that is known only to the facilitator. Unfortunately, this limits the possibility for other learners to read and comment on blog posts. Another option is to use a nickname that is known for the facilitator.

Therefore: It should be recommended for learners to write under a nickname, if the course involves sensitive discussion topics. The nickname should be known to the facilitator and depending on the context also for other learners.

Nicknames (or learners' real names, if preferred) are displayed in BLOGROLL (18). Other patterns related to the learners' identity are ABOUT PAGE

(16) and PERSONAL LEARNING CONTRACT (17). This pattern addresses the challenge of establishing and keeping the community gravity (C13).

Pattern 16: About page

This pattern deals with introducing learners to each other. It is connected to other identity-related pattern of using NICKNAMES (15).

Blog-based open online course may have a large number of participants that do not know each other. One option to introduce learners to each other is to write a blog post with a personal introduction. However, this post will soon become hidden behind more recent posts. Also, learners often use the same blog for several courses. This would result in multiple personal introduction posts. Another option is to write a personal introduction on a page that is displayed separately from blog posts. The WordPress blogging platform has an example page named *About* that is set up with every new installation.

Therefore: Learners should be guided to use the *About* page for writing their personal introduction. This personal introduction should also include their photo or avatar. As blog pages support embedding, this could also feature a short video greeting from the learner. This pattern is named after a feature in WordPress blogging platform. Some other blogging platforms may have a different place for writing a short personal introduction (e.g. sidebar and profile page in Blogger).

This pattern addresses the challenge of establishing and keeping the community gravity (C13).

Pattern 17: Personal learning contract

This pattern deals with supporting learners to set up their personal learning goals and strategies. It is linked to the other identity-related pattern of using NICKNAMES (15).

Blog-based open online courses attract a variety of participants with different goals. Learner-centered approaches are needed to keep learners motivated. One possible method to engage learners in planning their personal learning is to use learning contracts. Knowing learners' goals helps the facilitator to direct the course according to learner needs. Having a large set of learning contracts would also open up possibilities for connecting learners with similar goals, providing visualizations of learning contract data and performing learning analytics.

Therefore: Participants should be encouraged to establish their personal learning goals and strategies. This could be done through writing personal learning contracts. The facilitator and other learners should be able to give feedback to learning contracts. Learning contracts are typically elaborated and revised during the course. At the end of the course, learning contracts are used for self-evaluation. The tool used for writing learning contracts should support versioning and commenting of specific parts of learning contracts.

The facilitator would write a SUMMARY POST (22) based on personal learning contracts. This pattern is related to two design challenges: supporting learners with setting up their personal learning goals and strategies (C10) and commenting and versioning of learning contracts (C17).

Pattern 18: Blogroll

This pattern deals with providing access to other learners' blogs. It is related to two broader patterns: OPEN ENROLLMENT (14) and NICKNAMES (15).

In blogs, a common way of listing related blogs is using a links menu that is displayed on the sidebar. This links menu is known as *blogroll*. In open online courses, blogroll could be used for listing course participants and their blogs. However, with a large number of participants, it is not feasible to manage the blogroll manually.

Therefore: Blogroll should be used in course blog for providing access to all participant blogs. The coordination platform for blog-based open online courses should support keeping the blogroll updated. EduFeedr provides a blogroll code, that could be copied to the sidebar widget in the WordPress blog. A more advanced coordination platform could provide an embeddable blogroll widget that is updated automatically.

Blogroll pattern addresses the lack of coordination structures for managing blog-based courses (C15).

Pattern 19: Course tag

This pattern deals with annotating course-related resources in various online platforms. It is related to a larger pattern about BEING OPEN FOR LURKING (13).

In a typical blog-based open online course, a selection of other online platforms are used in addition to blogs. Common examples include Twitter for microblogging, SlideShare for presentations and YouTube for videos. Many of these platforms allow users to describe published content with tags. It is possible to link to a page that lists all resources having the same tag. Some of the platforms also provide RSS feed for each tag.

Therefore: The facilitator should suggest a course tag and guide participants to use this tag when publishing course related content in various online platforms. The course blog should link to a tag page in commonly used online platforms. In a more advanced case, a course coordination platform could also aggregate new resources using RSS feeds.

Resources tagged with a course tag could be presented in a similar way as AGGREGATED DISCUSSIONS (20). This pattern is related to the lack of coordination structures for managing blog-based courses (C15).

Pattern 20: Aggregated discussions

This pattern deals with combining online discussions that are fragmented between different platforms. It is related to broader patterns such as REFLECTIVE ASSIGNMENTS (21) and COURSE TAG (19).

One of the challenges of blog-based learning environments is the fragmentation of discussions. A coordination tool for blog-based courses could aggregate blog posts and comments from the course blog. A simple approach would mean displaying a fixed amount of most recent content. Depending on the number of participants and activity of discussion, there may be a need for highlighting certain posts or displaying only a selection of content. It is also important to consider that some people prefer to use their own feed reader.

Therefore: The coordination platform for blog-based open online courses should aggregate new blog posts and comments from participants' blogs. EduFeedr displays aggregated posts and comments in the course front page. In addition to displaying aggregated comments, the coordination tool should provide RSS feeds that allow learners to use their preferred feed reader for following course discussions. EduFeedr provides combined RSS feeds in OPML format for all course blogs.

This pattern addresses two design challenges: the fragmentation of discussions in blog-based courses (C14) and lack of awareness support mechanisms (C16).

Pattern 21: Reflective assignments

This pattern deals with assignments in blog-based open online courses.

Assignments are more typically associated more with formal education rather than with informal learning. However, they provide a way in which to frame the learning activities in blog-based courses. It is a challenge to come up with assignments that prompt all learners to submit original and valuable ideas related to the same problem. Assignments that are too strictly defined may compromise the originality of the learners' posts.

Therefore: Blog-based open online courses should have an individual blogging assignment with each major topic. Assignments should be posted with a regular interval, typically weekly or bi-weekly. The nature of assignments should encourage discovery learning, reflection and discussion. Often the assignment may consist of a theoretical and practical part, both of which should be reflected in a blog post. Learners' posts in blog-based courses should be seen as an important part of the learning content.

As one of the central patterns, it is related to four smaller patterns. Learners' blog posts submitted for assignments are displayed under AGGREGATED DISCUSSIONS (20) and provide data for LEARNING ANALYTICS VISUALIZATIONS (23). The facilitator will write SUMMARY POSTS (22) based on learners' work and use OPEN BADGES FOR ASSESSMENT (24). This pattern addresses the pedagogical design challenge regarding the danger of overscripting (C12).

Pattern 22: Summary posts

This pattern deals with summarizing course topics. It is related to broader patterns regarding REFLECTIVE ASSIGNMENTS (21) and PERSONAL LEARNING CONTRACTS (17).

It is not realistic for the course facilitator to comment on all blog posts that evoke thoughts. Also, the facilitator has to keep in mind that he/she should create opportunities for discussion, not have a leading role in the discussion. On the other hand, learners see comments and feedback as a motivating factor. Some simple ways to acknowledge learners' for their blog posts is to like good posts (feature available in WordPress) and to write a summary that contains links to the best learners' posts.

Therefore: The course facilitator should write a summary post for each assignment. This summary post should outline the main themes from the blog posts, cite interesting thoughts, link to the most active comment discussions, and point out possible controversies or misunderstandings. When mentioning specific learners, the summary should contain a link to their blog posts. The course coordination platform could track links to learner blogs and use this information for learning analytics and visualizations.

Summary posts address three design challenges: keeping the learner motivation throughout the learning project (C11), establishing and keeping the community gravity (C13), and the lack of awareness support mechanisms (C16).

Pattern 23: Learning analytics visualizations
This pattern deals with visualizing the data about REFLECTIVE ASSIGNMENTS (21) and other learning activities.

Blog posts, comments and links between the blogs provide an interesting data set that could be used for learning analytics and visualizations. Learners would benefit from the possibility of being able to compare themselves with their peers. Following a large number of participants is easier if it is known which ones are still actively participating in course activities. The facilitators would also benefit from identifying learners who are alone in the community and might need support. As the learning activities in blog-based courses are public, then the learning analytics based on this data could also be public. Privacy concerns could be addressed by other measures such as by using NICKNAMES (15).

Therefore: The coordination platform for blog-based open online courses should provide learning analytics based on blog posts, comments and links between the blogs. EduFeedr provides a progress visualization that displays submitted assignments and social network visualization that is based on comments and links between learners' blog posts. All these visualizations are public. Depending on the capabilities of the coordination platform there could be various additional visualizations, as discussed in Põldoja et al. (2016).

This pattern addresses the lack of awareness support mechanisms (C16).

Pattern 24: Open badges for assessment
This pattern deals with assessment and recognition of learners' competencies acquired through REFLECTIVE ASSIGNMENTS (21).

Blog-based open online courses raise a number of assessment issues such as private grading and recognizing the work of informal participants (Põldoja & Laanpere, 2014). One solution for these issues is the use of open badges. A badge scheme for the course should be developed so that it motivates learners and provides a choice of learning activities. Badges could be awarded manually by the facilitator or automatically based on learning analytics.

Therefore: Open badges should be used for assessing learners' posts and recognizing any achieved competencies in blog-based open online courses. In order to distinguish exceptional works, there should be several levels of badges (for example a "Gold" badge that is awarded for outstanding blog posts). Learners should have multiple possible paths for doing the assignments and acquiring badges. In addition to badges awarded for blogging assignments, there could be other types of badges for recognizing a learners' contribution to the course (activity in discussions, providing support for other learners, etc.).

The use of open badges for assessment is related to the following pedagogical design challenges: supporting learners with setting up their personal learning goals and strategies (C10), keeping the learner motivation throughout the learning project (C11), and the danger of over-scripting (C12).

Summary

In the context of blog-based open online courses, only the technical design challenges were addressed with patterns identified from the implementation of the EduFeedr tool. EduFeedr supports OPEN ENROLLMENT (14), PROVIDES BLOGROLL (18), AGGREGATED DISCUSSIONS (20) and LEARNING ANALYTICS VISUALIZATIONS (23). Support for COURSE TAG (19) is partly implemented; the actual aggregation of content from Web 2.0 platforms that provide RSS feeds for tags is not implemented. Pedagogical and socio-cultural design challenges were addressed with patterns that described pedagogical approaches and the use of other online tools such as blogging platforms.

The mapping of design challenges and design patterns for blog-based open online courses is presented in Figure 17. In this context, the central design challenges were (C15) lack of coordination structures for managing blog-based courses, (C16) lack of awareness support mechanisms, and (C13) establishing and keeping the community gravity.

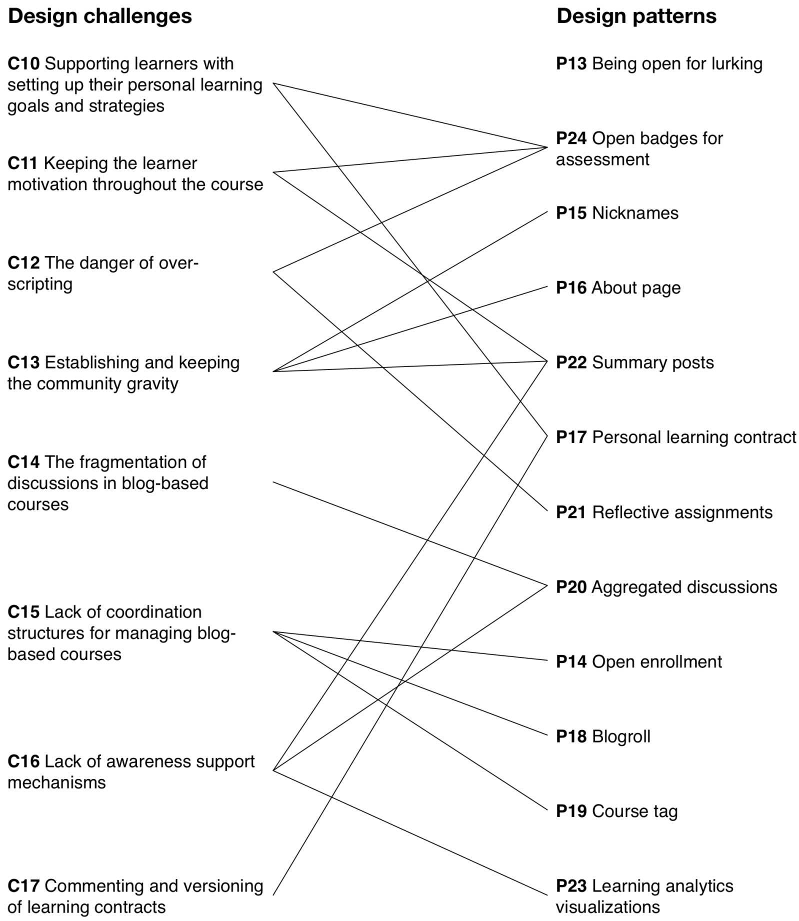


Figure 17. Mapping of design challenges and patterns for blog-based open online courses

From the digital ecosystems perspective, blog-based open online courses have certain differences when compared with OER authoring platforms. Whereas collaborative authoring of OER's takes place in a central authoring platform, blog-based open online courses are organized in a distributed learning environment that consists from a number of blogs and other online tools. Interaction between the blogs and other online tools used in the course is achieved through AGGREGATED DISCUSSIONS (20) and the use of a COURSE TAG (19). In the context of blog-based open online courses, a balance must be achieved between the learners' different expectations, goals and contributions to the course. BEING OPEN FOR LURKING (13) means that learners do not have to enroll in the course if they only want to access the content or follow course discussions. Encouraging learners to write PERSONAL LEARNING CONTRACTS (17) and providing different learning paths through using OPEN BADGES FOR ASSESSMENT (24) supports the balance between different learning goals. Balance in the learning community can be also strengthened through carefully written SUMMARY POSTS (22) that refer to the learners' blog posts. Blogs and blog posts are loosely connected through BLOGROLL (18), AGGREGATED DISCUSSIONS (20), and SUMMARY POSTS (22). The most obvious example of self-organization in blog-based open online courses is open enrollment (14). Having public LEARNING ANALYTICS VISUALIZATIONS (23) also contributes to learners' self-organization.

Some of the patterns identified in the context of collaborative authoring of OER's could be also used in blog-based open online courses. For example, it is possible to add external content to blog posts through EMBEDDING (3). LINKEDNESS (4) is also a more general pattern that is used in many online contexts. Design patterns identified in this study provide input for discussing the general structure and components of the open education ecosystem.

6.3 The Structure and Components of the Open Education Ecosystem

Previous sections examined the design challenges and recommended design patterns for two specific contexts of open education. These patterns approached open education as a digital ecosystem that consists of connected online learning tools and various stakeholders. In order to successfully apply these patterns, it is also important to understand the general structure and components of the open education ecosystem. The Oxford English Dictionary defines structure as "the arrangement and organization of mutually connected and dependent elements in a system or construct" ("structure, n.", 2014). Structure and components are commonly used concepts when describing ecosystems (Begon et al., 2006). Generally, the structure of an ecosystem is composed of biotic and abiotic components that share relationships and influences between them.

In Section 2.3.3, the open education ecosystem is defined as a learning ecosystem that consists of tools, services, resources and stakeholders who share a common set of values. The core value that defines the extent of the OEE is openness. The dissertation adopts the concept and representation of the learning ecosystem (Chang & Guetl, 2007; Gütl & Chang, 2008) as a basis for presenting the structure of the open education ecosystem. The approach of these researchers (elaborated in Section 2.3.3) defined the biotic components of the ecosystem as learning stakeholders and abiotic components as learning utilities. Conditions of the ecosystem were influenced by internal and external influences. The extent of the ecosystem was limited by the learning environmental boundaries. A simplified representation of the open education ecosystem is presented in Figure 18.

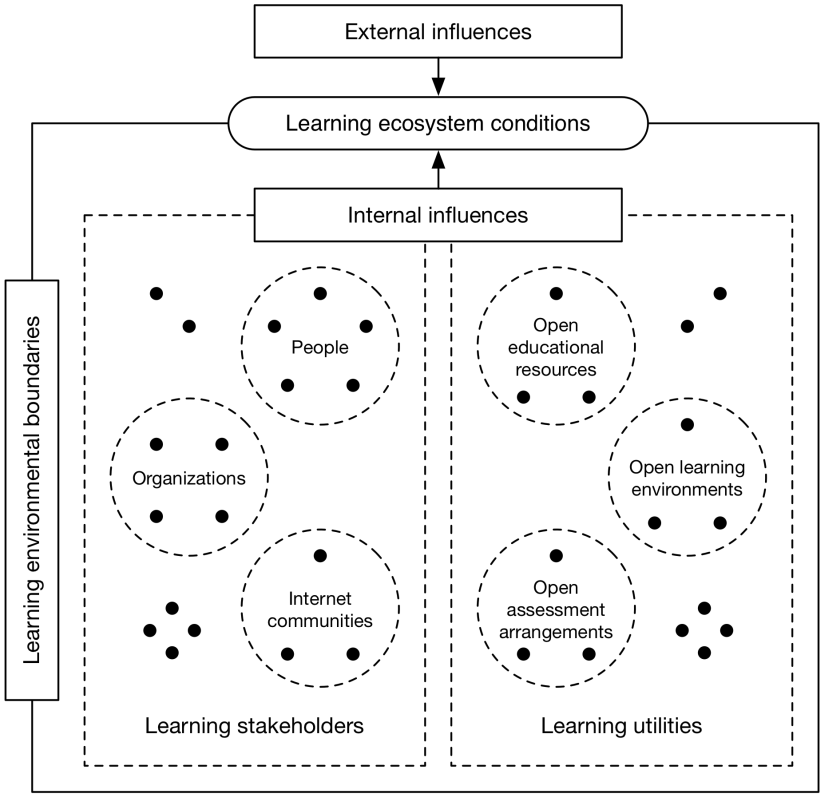


Figure 18. Simplified representation of the open education ecosystem (based on Gütl & Chang, 2008)

Design cases included in this dissertation focused on three contexts: authoring and sharing platforms for open educational resources, blog-based open online courses, and assessment and recognition of competencies. These three contexts identify the three types of learning utilities for the open education ecosystem. Generally, these types of learning utilities could be defined as open educational resources, open learning environments, and open assessment arrangements. Learning stakeholders include different people, organizations and Internet communities who are using the learning utilities or influence the ecosystem in some other way.

This study is approaching the open education ecosystem as one global digital learning ecosystem. In order to understand the extent of the OEE, its boundaries must be defined more precisely. As stated earlier, the core value that limits the extent of the OEE is openness. However, as the theoretical overview in Section 2.2 demonstrates, openness in education can be understood from multiple perspectives. In this study, the learning environmental boundaries of the open education ecosystem are defined through three characteristics: (1) open access, (2) open licensing, and (3) open participation. At the very basic level, there must be no-cost access that enables the reuse of educational content. Open licensing enables revising, remixing and redistributing of educational resources. In addition to content, open education covers various educational activities and practices. The general characteristic of these activities is free and open participation. There are also situations where these boundaries may be disputed. Is it an open educational resource that is published under a Creative Commons license that does not allow the creation of derivative works? Nowadays, many courses that are called MOOCs provide only free participation and access to learning resources, but the learning resources itself are not published under open licenses. In that case it is possible to argue that learning activities in the course belong to the open education ecosystem, but the educational resources are outside the boundaries of the OEE. Behind the boundaries of the OEE there are other digital learning ecosystems that are not based on the principles of openness (e.g. xMOOC platforms, iTunes U[29]).

To discuss the internal and external influences on the open education ecosystem, we must look more precisely on the learning stakeholders and learning utilities that belong to the OEE. A better understanding of learning stakeholders involved in the open education ecosystem can be achieved through the design process. As discussed in Section 2.4.1, design can be seen both as a process and as a communication. This communication involves various stakeholders that are described in design artifacts such as personas and scenarios. In participatory design approach, these stakeholders are also involved in various phases of the design process. A set of stakeholders can be derived from personas and scenarios developed in five design projects included in this dissertation. Additional stakeholders were identified during the actual use of software prototypes. However, it must be stated that this study does not provide a complete list of learning stakeholders for the open education ecosystem. Designing for different contexts of open education may reveal additional learning stakeholders. A more detailed representation of learning stakeholders is presented in Figure 19.

[29] http://www.apple.com/education/itunes-u/

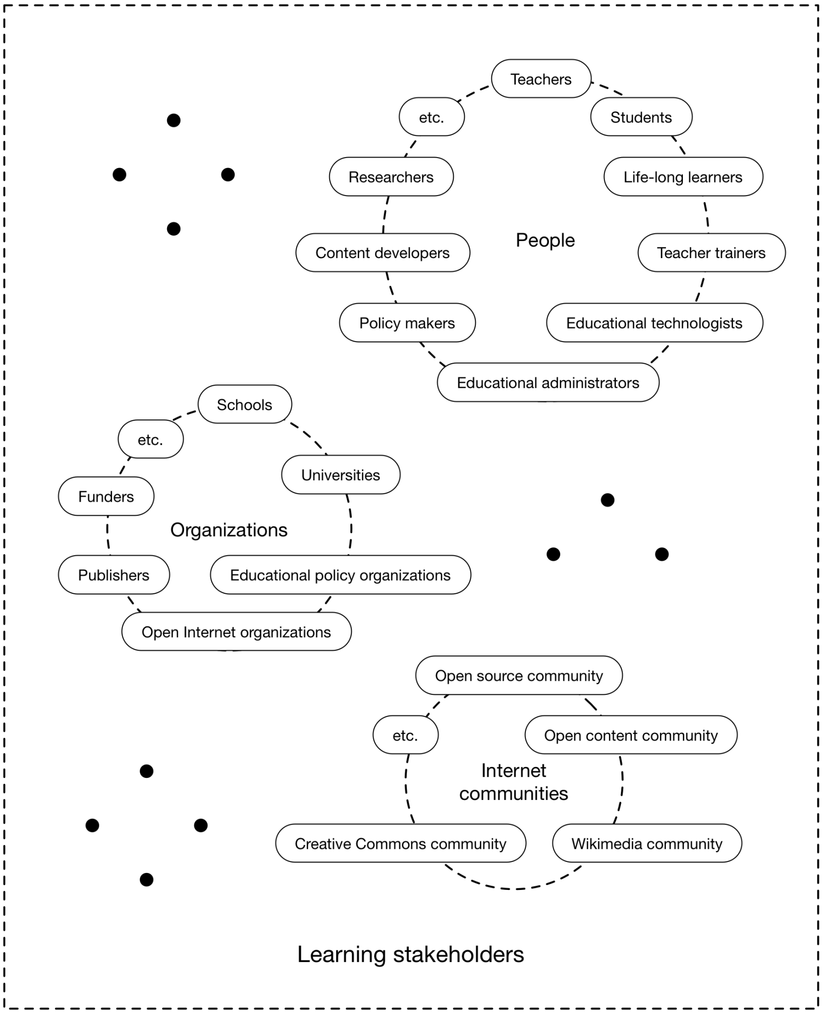


Figure 19. Learning stakeholders of the open education ecosystem

The target group of online learning designed tools in this study includes teachers and students from schools and from higher education. The OER tools LeMill and PILOT were designed with a focus on schools, while EduFeedr and LeContract were targeting higher education and life-long learning. DigiMina was aimed at school teachers and teacher education students. Assessment of teachers' educational technology competencies is a complex issue that involves additional stakeholders such as teacher trainers, educational technologists and school administration, educational policy makers, and researchers. For OER tools, professional content developers were also seen as possible contributors. Schools, universities, educational policy organizations, publishers, funders, and open Internet organizations are all organizations that can be seen as important stakeholders in the open education ecosystem. Thirdly, there are various communities that are involved in shaping the open education ecosystem. These include open source community, specific open content communities such as Creative Commons and Wikimedia communities, and a wider community of amateur authors who publish their works under open licenses. Taking into consideration the interests of various learning stakeholders is crucial for achieving the balance and sustainability of the open education ecosystem.

The learning utilities part of the open education ecosystem includes tools and resources that are used in various areas of open education. This study identified three core areas of learning utilities: (1) open educational resources, (2) open learning environments, and (3) open assessment arrangements. These areas of learning utilities are presented in Figure 20.

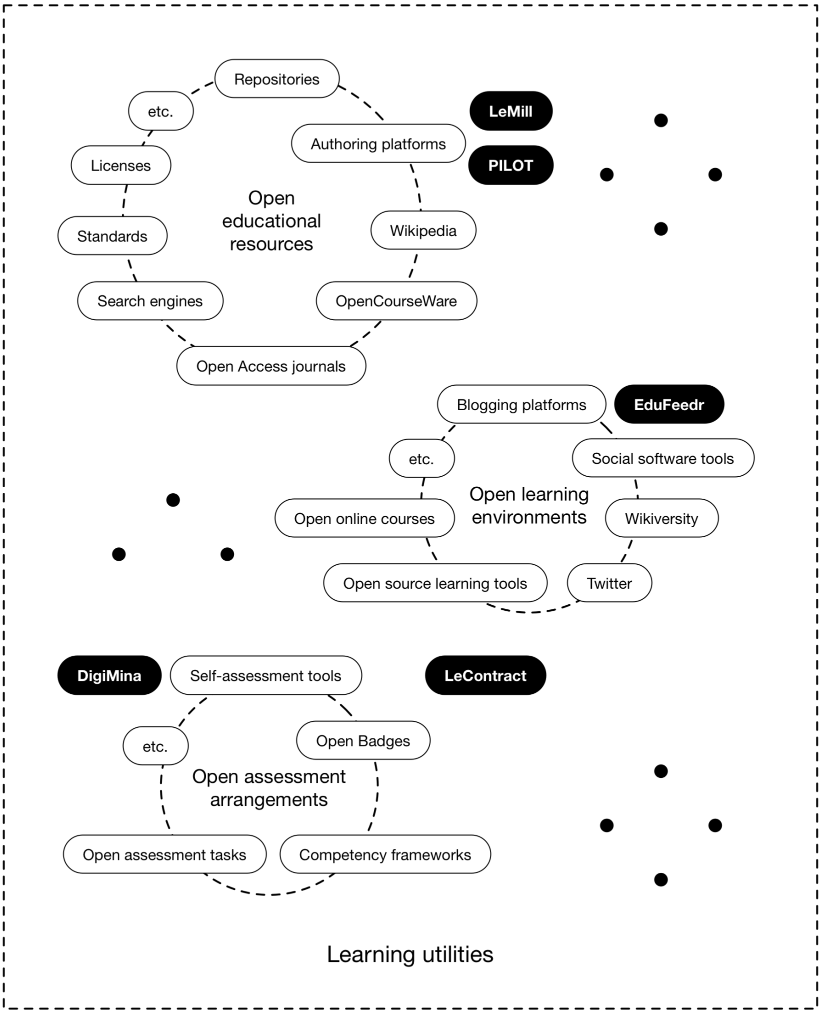


Figure 20. Learning stakeholders of the open education ecosystem

Open educational resources have been the main area of development in open education. A number of repositories have been set up for sharing OER's. There are both special authoring platforms for OER's and generic learning resource authoring tools that are used for open education. LeMill and the PILOT template are examples of authoring tools. Several universities have set up OpenCourseWare portals for distributing full courses. A lot of valuable content for open education is developed in Wikipedia and other wikis run by the Wikimedia Foundation. At higher levels of education, research publications are also an important component of educational content. Outcomes of scientific research can be published in open access journals and preprint versions of publications can be made openly available. In order to find and reuse resources there is a need for search engines, interoperability standards, and open licenses.

Open learning environments are an area of the open education ecosystem where open online courses and various other learning activities take place. Tools used for setting up open learning environments include blogging platforms, microblogging platforms such as Twitter, educational wikis, and other social software tools. There is a variety of open source learning tools that could be used in open learning environments. Depending on the way they are set up and used, learning management systems such as Moodle could also be part of an open learning environment. From the tools designed in this study, EduFeedr belongs clearly to open learning environments. LeContract is related both to open learning environments and to open assessment arrangements.

Open assessment arrangements include self-assessment tools that can be used by the learners, competency frameworks, assessment tasks and task authoring tools, and tools for creating, issuing, storing and displaying Open Badges. DigiMina is a self- and peer-assessment tool that was implemented for assessing teachers' educational technology competencies. However, with a different competency model and assessment tasks it could be used for assessing other types of competencies. Assessment tasks published under open licenses could be also considered as open educational resources.

The interoperability between the learning utilities is enabled by following the standards and design principles of the open web. For example, blog-based courses coordinated with EduFeedr may refer to learning resources published in LeMill. These learning resources may include embedded media content from other web sites. Information about new blog posts, comments or learning resources is aggregated using RSS feeds.

In addition to specific learning tools, design patterns that these tools are based on, can also be seen as components of the ecosystem. These design patterns can be reused for addressing similar design challenges when designing other learning tools for open education.

This structure of learning utilities can be related to earlier discussions on tools and services for open education. In the early 1970s, Illich (1971/2011, p. 78–79) proposed the idea of learning webs that had four types of networks: reference services to educational objects, skill exchange networks, peer-matching networks for finding similar learners, and reference services to educators. LeMill and other OER tools can be seen as reference services to educational objects. DigiMina is an example of a skill exchange network that allows teachers to create public competency profiles. LeContract should help learners to find peers with similar learning goals. Illich's idea of listing educators who are willing to offer their services has been realized in a form of open online courses that are offered through various platforms, including EduFeedr. Wiley (2015) proposed four parts for the open education infrastructure: open credentials, open assessments, open educational resources, and open competencies. In this thesis, open credentials (Open Badges) and open competencies are both seen as part of open assessment arrangements. By listing these as separate parts of the infrastructure, Wiley emphasized that the focus of research and development should expand from OER's to these areas of open education. Notably, Wiley's interpretation missed open learning environments, the area where the actual social learning activities take place.

Learning ecosystem conditions depend on internal and external influences. These influences are related to design challenges described in Section 6.1. Typically, the design challenges cannot be categorized strictly as internal or external influences. For example, challenges such as establishing the community gravity (C13) and keeping learners motivated (C11) are influenced both by internal and external factors. Technical design challenges can be seen as internal influences, when they are related to the tools used only for open education. However, in many cases learning tools are used in different contexts. Challenges related to new pedagogical methods (C2) and competency frameworks (C18, C19) can be considered as external influences. There are additional internal and external influences that are not identified as design challenges in this study. These internal influences are related to business models and sustainability of the ecosystem. External influences include also educational policies and funding.

6.4 Summary

This dissertation studied three areas of open education through five design cases. The contexts studied include collaborative authoring of OER's, blog-based open online courses, and assessment and recognition of competencies. In each design case, important design challenges were identified. As a first result, this dissertation summarizes 22 design challenges for open education. Secondly, this study focused on two contexts where the designed tools were taken into long-term use by a larger group of teachers and learners. As a second result, 24 design patterns were identified for collaborative authoring of OER's and blog-based open online courses. These design patterns address the design challenges identified in this study. The third result of the dissertation is the conceptual model of the open education ecosystem. This model describes the biotic and abiotic part of the ecosystem, its boundaries, and influences affecting the conditions of the ecosystem. Three main types of learning utilities in the open education ecosystem include open educational resources, open learning environments, and open assessment arrangements. Both design patterns and design challenges are also components of the ecosystem. The theoretical and practical value of these results will be discussed in the next chapter.

7. Discussion

The final chapter discusses the theoretical and practical implications of this study. Discussing the validity, reliability and limitations of the study provides a critical assessment of the research outcomes. The chapter ends with providing possible directions for further research.

7.1 Theoretical Implications

In recent years there has been a number of doctoral dissertations on open education. The majority of these works approach open education from the theoretical research perspective and focus on a specific area of open education such as open educational resources (Algers, 2015; Kozinska, 2013; Porter, 2013), open courses and learning environments (Meiszner, 2010; Spoelstra, 2015), and economical issues (Liu, 2011; Ondercin, 2011). While some of these works involve the design of pedagogical interventions for open online courses (Meiszner, 2010; Spoelstra, 2015) and open educational resources (Algers, 2015), none of these works establish design research as the main approach for studying open education.

My dissertation has combined design practice with theoretical design studies. Basing the study on interaction design projects has made it possible to involve teachers, learners and other stakeholders from the early phases of the design process to the actual use of the designed prototypes. Observing the actual use of designed prototypes has provided an important input for understanding how these tools relate to other components of the open education ecosystem. Furthermore, focusing on different aspects of open education has been important for recognizing the general structure of the open education ecosystem. Thus, the value of this dissertation lies in taking a wider perspective on open education and studying it through the design practice.

The theoretical results of the dissertation contribute mainly to the field of open education by providing a deeper understanding of the open education phenomena in the era of digital ecosystems. Some of the results are valuable also for other related fields of research. For example, some of the identified design challenges and patterns may also be useful in other contexts of technology-enhanced learning such as designing virtual learning environments.

Another theoretical result is in the area of design challenges for open education. Although there are earlier studies about the design challenges for open educational resources (Conole & McAndrew, 2010) and MOOCs (Beaven, Hauck, Comas-Quinn, Lewis, & de los Arcos, 2014), my research provides a comprehensive set of design challenges. Current research on design patterns for open education focuses mainly on pedagogical patterns for reuse of OER (Conole, McAndrew, & Dimitriadis, 2011) and design of MOOCs (Hatzipanagos, 2015; Koppe et al., 2015; Lackner, Ebner, & Khalil, 2015; Littlejohn & Milligan, 2015; Liyanagunawardena, Kennedy, & Cuffe, 2015; Mor & Warburton, 2015). This study differs from the related work by providing a set of patterns that cover both pedagogical practices and their implementation in software.

7.2 Practical Implications

The results of this study provide practical value for designers and other stakeholders involved in designing online learning tools for technology-enhanced learning in general and open education in particular.

At first, this study helps in the understanding of complex and interlinked design challenges related to collaborative authoring of OER, blog-based open online courses, and assessment of competencies. While every design context has its own specific design challenges, the set of challenges identified in this study provides guidance and examples that help designers to translate the wicked problems common in technology-enhanced learning field to more specific design challenges in their design situation.

Design patterns about collaborative authoring of OER are valuable for interaction designers who design authoring tools, repositories and other software for creating, sharing and reusing learning resources. While this study focused specifically on open educational resources, many of these patterns are also relevant for non-open digital learning resources. Several patterns that were successful in LeMill have been later implemented in other online learning platforms developed in Estonia (Koolielu[30], e-Koolikott[31]), for example TOOL DESCRIPTIONS (9), COLLECTION (10), and TEACHING AND LEARNING STORY (11).

Design patterns about blog-based open online courses are valuable both for interaction designers as well as teachers and instructional designers developing online courses. Open online courses applying the design patterns described in this study end up to be as recipe books that allow other educators to learn from good pedagogical practices and use them in their own courses. Design patterns provide a structured way of documenting these practices.

The practical value for many teachers and learners are the actual online learning tools designed and developed during this study. Two tools in particular — LeMill and EduFeedr — have been taken into a wider use. These tools have not been designed to support teachers' existing practices, but to influence teachers in changing their practices towards more open and personal learning. Therefore, this study has contributed to the educational change.

---

[30] http://koolielu.ee

[31] https://e-koolikott.ee

The results of this study are important also for policy making. Ecosystem thinking would help policy makers to understand which learning stakeholders should be involved in design and decision making processes, what are the learning utilities needed to support open education, and how different components of open education are related to each other. It is also necessary to think about how open education fits into a larger digital ecosystem that is an important part of daily life for modern learners.

7.3 (In)validity and (Un)reliability

Academic research is assessed through qualities such as *validity* and *reliability*. In a basic level, validity can be described as the degree to which a particular research instrument measures what it is supposed to measure (Cohen et al., 2007, p. 133). Reliability means that two or more researchers studying the same phenomenon should achieve compatible results when following the same procedures with a similar group of participants in a similar context. Cohen et al. (2007, p. 148) point out that in qualitative research the strict replication of research procedures is sometimes problematic or even undesirable, thus reliability cannot be approached in a same way as in quantitative research. This is also true in design research. Fallman and Stolterman (2010) argue that it is very unlikely that two designers would come up with exactly the same result, even if they would have the same design context, materials, tools and users. They dispute the fact that in case of design research, one could value the "invalidity" and "unreliability" that comes from the creative design process and different ways of seeing things.

According to Fallman and Stolterman (2010), the three forms of interaction design research (discussed in Chapter 3) should be assessed in a different way, as each form of research has its own purposes, methods, internal logic and outcomes. In design practice, the most important assessment criteria are the relevance of the final design for the client and users — it has to be useful and make sense. The process of design exploration is assessed by how well it opens up critical and creative approaches that challenge the mainstream design solutions. The degree to which the results can be generalized provides the assessment of the design studies.

This study has used multiple approaches to achieve validity and reliability. In order to increase the internal validity, the design cases involved in this study have used multiple design researchers, involved participants as designers, and applied peer-examination of research data, as recommended by Cohen et al. (2007, p. 135). The design processes themselves involve multiple methods and types of data, which has increased the validity of the design decisions. The use of the triangulation of multiple methods and data sources, as discussed in Section 3.2, supported the validity of the design studies phase.

7.4 Limitations of the Study

This study has also a number of limitations that should be discussed. The long time frame that was required to complete the study can be seen both as a limitation and as an advantage. The design challenges for open educational resources were identified a decade ago. Some of these challenges are not that critical today, for example the usability of OER authoring tools has improved (challenge 8). On the other hand, the long duration of the study helped to take a wider perspective on open education and witness the rise of new areas in open education such as open online courses and open badges.

The second limitation is related to the fifth design case about web-based self- and peer-assessment of teachers' educational technology competencies. The DigiMina tool was not taken into wider use as the initial plans to integrate it with the Estonian national education portal did not succeed. Therefore this tool was evaluated only in a pilot study with 50 teachers and part of the assessment tasks. Due to lack of real life use it was not possible to identify design patterns for assessment and recognition of competencies.

Thirdly, the design patterns have not been validated in participatory design workshops. Mor and Warburton (2015) have proposed the participatory pattern workshop methodology, in which design patterns are developed in a collaborative way through a series of workshops. In my study, the participatory design sessions were organized in the early phases of each design case to discuss and evaluate the scenarios about the designed tools. Successful design patterns were identified and documented by me after the tools were taken into actual use. Thus, the patterns are based on stakeholders' feedback and end users activities. Validating the patterns through participatory design workshops is one possible task for future research.

7.5 Recommendations for Further Research

This study covered a selection of topics related to open education, such as open educational resources, open learning environments, and open assessment. Having a wider perspective of the area studied opens up a number of possible directions for future research.

As mentioned in the previous section, the set of design patterns developed in this study could be validated through participatory pattern workshops with various learning stakeholders. These workshops would also provide the possibility of identifying additional patterns and extending the pattern language.

Regarding open educational resources, the most interesting direction for future research is related to creating adaptations of OER's. As discussed in Section 6.2.1, the current implementation of the ADAPTATIONS (7) pattern in LeMill was not successful. The increasing number of open educational resources makes reuse an important issue. Thus, there is a need for flexible and user-friendly solutions for adapting the learning resources to a specific context.

With open learning environments, two possible future directions are related to learning analytics and the danger of over-scripting. The current implementation of EduFeedr had some basic learning analytics visualizations such as learner progress and social network. However, detailed analysis of the aggregated blog posts and comments opens up a number of additional possibilities for learning analytics. Visual representation of this data provides awareness support for learners and facilitators regarding their personal learning and ongoing learning activities. The danger of over-scripting in blog-based courses is a more pedagogical issue that needs further research. Suitable pedagogical practices for blog-based open online courses could be described as additional patterns.

For me personally, the most interesting future direction is to move back to the areas of design practice and design exploration. I am interested in exploring the possibility of combining personal learning contracts, self- and peer-assessment, and open badges. The future prototype of LeContract could provide a visual learning path in which learners can specify their personal learning goals and open badges that they plan to achieve. The assessment could involve some aspects of self- and peer-assessment. Implementing such a system in practice would make it possible to identify a set of design patterns for open assessment.

References

Alexander, C. (1979). *The Timeless Way of Building*. New York, NY: Oxford University Press.

Alexander, C., Ishikawa, S., & Silverstein, M. (1977). *A Pattern Language: Towns, Buildings, Construction*. New York, NY: Oxford University Press.

Algers, A. (2015). *Open Learning in Life Sciences: Studies of open educational resources in animal welfare and work-based learning in food science* (Doctoral dissertation). Chalmers University of Technology & University of Gothenburg, Gothenburg. Retrieved from http://hdl.handle.net/2077/40580

Alpert, D., & Bitzer, D. L. (1970). Advances in Computer-based Education. *Science, 167*(3925), 1582–1590. http://doi.org/10.1126/science.167.3925.1582

Anderson, C., & Wolff, M. (2010, September). The Web Is Dead. Long Live the Internet. *Wired*. Retrieved from http://www.wired.com

Anderson, G., Boud, D., & Sampson, J. (1996). *Learning Contracts: A Practical Guide*. New York: Routledge.

Anderson, T., & Dron, J. (2011). Three Generations of Distance Education Pedagogy. *The International Review of Research in Open and Distance Learning, 12*(3), 80–97.

Atkins, D. E., Brown, J. S., & Hammond, A. L. (2007). *A Review of the Open Educational Resources (OER) Movement: Achievements, Challenges, and New Opportunities*. The William and Flora Hewlett Foundation.

Attwell, G. (2007). Personal Learning Environments - the future of eLearning? *eLearning Papers, 2*(1), 1–8.

Augar, N., Raitman, R., & Zhou, W. (2004). Teaching and learning online with wikis. In R. Atkinson, C. McBeath, D. Jonas-Dwyer, & R. Phillips (Eds.), *Beyond the Comfort Zone: Proceedings of the 21st ASCILITE Conference* (pp. 95–104). ASCILITE.

Baggetun, R., Rusman, E., & Poggi, C. (2004). Design Patterns For Collaborative Learning: From Practice To Theory And Back. In L. Cantoni & C. McLoughlin (Eds.), *Proceedings of EdMedia World Conference on Educational Media and Technology* (pp. 2493–2498). AACE.

Baker, F. W., III, & Surry, D. W. (2013). Open Education Designs: A Taxonomy for Differentiating and Classifying Open Learning Environments. In R. McBride & M. Searson (Eds.), *Proceedings of Society for Information Technology Teacher Education International Conference* (pp. 189–194). Chesapeake, VA: AACE.

Beaven, T., Hauck, M., Comas-Quinn, A., Lewis, T., & de los Arcos, B. (2014). MOOCs: Striking the Right Balance between Facilitation and Self-Determination. *MERLOT Journal of Online Learning and Teaching, 10*(1), 31–43. http://doi.org/10.1080/03098770903477102

Begon, M., Townsend, C. R., & Harper, J. L. (2006). *Ecology: From Individuals to Ecosystems* (4th ed.). Malden, MA: Blackwell Publishing.

Benjamin, L. T. (1988). A History of Teaching Machines. *American Psychologist, 43*(9), 703–712.

Berg, B. L. (2001). *Qualitative research methods for the social sciences* (4th ed.). Needham Heights, MA: Allyn & Bacon.

Berners-Lee, T., Cailliau, R., Groff, J. F., & Pollermann, B. (1992). World-Wide Web: The Information Universe. *Internet Research, 2*(1), 52–58. http://doi.org/10.1108/eb047254

Berners-Lee, T. (2010, December). Long Live the Web: A Call for Continued Open Standards and Neutrality. *Scientific American, 303*(6), 80–85.

Black, A. (1997). Lost Worlds of Culture: Victorian libraries, library history and prospects for a history of information. *Journal of Victorian Culture, 2*(1), 95–112. http://doi.org/10.1080/13555509709505940

Blanke, T. (2014). *Digital Asset Ecosystems: Rethinking crowds and cloud*. Kidlington: Chandos Publishing.

Bransford, J. D., Sherwood, R. D., Hasselbring, T. S., Kinzer, C. K., & Williams, S. M. (1990). Anchored Instruction: Why We Need It and How Technology Can Help. In D. Nix & R. Spiro (Eds.), *Cognition, Education, and Multimedia: Exploring Ideas in High Technology* (pp. 115–141). Hillsdale, NJ: Routledge.

Brinck, T., Gergle, D., Wood, S.D. (2002). *Usability for the Web: Designing Web Sites That Work*. San Francisco, CA: Morgan Kaufmann Publishers.

Briscoe, G., & De Wilde, P. (2006). Digital ecosystems: evolving service-orientated architectures. In *Bio-Inspired Models of Network, Information and Computing Systems*. http://doi.org/10.1109/BIMNICS.2006.361817

Briscoe, G., & De Wilde, P. (2009). Computing of applied digital ecosystems. In *Proceedings of the International Conference on Management of Emergent Digital EcoSystems* (pp. 28–35). New York, NY: ACM. http://doi.org/10.1145/1643823.1643830

Briscoe, G., Sadedin, S., & De Wilde, P. (2011). Digital Ecosystems: Ecosystem-Oriented Architectures. *Natural Computing, 10*(3), 1143–1194. http://doi.org/10.1007/s11047-011-9254-0

Brouns, F., Koper, R., Manderveld, J., Van Bruggen, J., Sloep, P., van Rosmalen, P., et al. (2005). A first exploration of an inductive analysis approach for detecting learning design patterns. *Journal of Interactive Media in Education, 2005*(3), 1–10.

Brown, D. M. (2010). *Communicating Design: Developing Web Site Documentation for Design and Planning* (2nd ed.). Berkeley, CA: New Riders.

Brown, J. S., & Adler, R. P. (2008). Minds on Fire: Open Education, the Long Tail, and Learning 2.0. *EDUCAUSE review, 43*(1), 16–32.

Browne, T., Holding, R., Howell, A., & Rodway-Dyer, S. (2010). The challenges of OER to Academic Practice. *Journal of Interactive Media in Education, 2010*(1), 3–15. http://doi.org/10.5334/2010-3

Calvani, A., Cartelli, A., Fini, A., & Ranieri, M. (2008). Models and Instruments for Assessing Digital Competence at School. *Journal of E-Learning and Knowledge Society, 4*(3), 183–193.

Camilleri, A. F., Ehlers, U.-D., & Pawlowski, J. (2014). *State of the Art Review of Quality Issues related to Open Educational Resources (OER)* (Report No. EUR 26624 EN). Retrieved from Institute for Prospective Technological Studies website: http://is.jrc.ec.europa.eu/pages/EAP/documents/201405JRC88304.pdf

Carroll, J. M. (2000). *Making Use: Scenario-Based Design of Human-Computer Interactions*. Cambridge, MA: The MIT Press.

Carroll, J. M., Neale, D. C., Isenhour, P. L., Rosson, M. B., & McCrickard, D. S. (2003). Notification and awareness: synchronizing task-oriented collaborative activity. *International Journal of Human-Computer Studies, 58*(5), 605–632.

Casakin, H. P. (2007). Metaphors in Design Problem Solving: Implications for Creativity. *International Journal of Design, 1*(2), 21–33.

Chan, T.-W., Roschelle, J., Hsi, S., Kinshuk, Sharples, M., Brown, T., et al. (2006). One-to-one technology-enhanced learning: An opportunity for global research collaboration. *Research and Practice in Technology Enhanced Learning, 1*(1), 3–29.

Chang, E., & West, M. (2006). Digital Ecosystems A Next Generation of the Collaborative Environment. In *Proceedings of iiWAS2006* (pp. 3–23).

Chang, V., & Guetl, C. (2007). E-Learning Ecosystem (ELES) - A Holistic Approach for the Development of more Effective Learning Environment for Small-and-Medium Sized Enterprises (SMEs). In E. Chang & F. K. Hussain (Eds.), *2007 Inaugural IEEE International Conference on Digital Ecosystems and Technologies* (pp. 420–425). IEEE. http://dx.doi.org/10.1109/DEST.2007.372010

Christiansen, J.-A., & Anderson, T. (2004). Feasibility of Course Development Based on Learning Objects: Research Analysis of Three Case Studies. *International Journal of Instructional Technology & Distance Learning, 1*(3), 21–38.

Chyung, S. Y. (2007). Invisible Motivation of Online Adult Learners During Contract Learning. *The Journal of Educators Online, 4*(1), 1–22.

Clow, D. (2013). MOOCs and the Funnel of Participation. In D. Suthers, K. Verbert, E. Duval, & X. Ochoa (Eds.), *Proceedings of the Third International Conference on Learning Analytics and Knowledge* (pp. 185–189). New York, NY: ACM Press. http://doi.org/10.1145/2460296.2460332

Coates, H., James, R., & Baldwin, G. (2005). A Critical Examination Of The Effects Of Learning Management Systems On University Teaching And Learning. *Tertiary Education and Management, 11*(1), 19–36. http://doi.org/10.1007/s11233-004-3567-9

Cohen, L., Manion, L., & Morrison, K. (2007). *Research Methods in Education* (6th ed.). Abingdon: Routledge.

Cohn, M. (2004). *User Stories Applied: For Agile Software Development*. Boston, MA: Addison-Wesley.

Conde, M. A., Garcia, F. J., Casany, M. J., & Alier, M. (2010). Applying Web Services to Define Open Learning Environments. In A. M. Tjoa & R. R. Wagner (Eds.), *Proceedings of the 21st International Workshop on Database and Expert Systems Applications* (pp. 79–83). Los Alamitos, CA: IEEE Computer Society. http://doi.org/10.1109/DEXA.2010.36

Conole, G., & McAndrew, P. (2010). OLnet: A New Approach to Supporting the Design and Use of Open Educational Resources. In M. Ebner & M. Schiefner (Eds.), *Looking Toward the Future of Technology-Enhanced Education* (pp. 123–144). IGI Global. http://doi.org/10.4018/978-1-61520-678-0.ch007

Conole, G., McAndrew, P., & Dimitriadis, Y. (2011). The Role of CSCL Pedagogical Patterns as Mediating Artefacts for Repurposing Open Educational Resources. In F. Pozzi & D. Persico (Eds.), *Techniques for Fostering Collaboration in Online Learning Communities* (pp. 206–223). IGI Global. http://doi.org/10.4018/978-1-61692-898-8.ch012

Conole, G., Scanlon, E., Mundin, P., & Farrow, R. (2010). *Interdisciplinary research: Findings from the Technology Enhanced Learning Research Programme*. London: University of London. Retrieved from http://www.tlrp.org/docs/TELInterdisciplinarity.pdf

Conole, G. (2014). A new classification schema for MOOCs. *International Journal for Innovation and Quality in Learning, 2*(3), 65–77.

Cooper, A., Reimann, R., & Cronin, D. (2007). *About Face 3: The Essentials of Interaction Design*. Indianapolis, IN: Wiley Publishing, Inc.

Couros, A. (2010). Developing Personal Learning Networks for Open and Social Learning. In G. Veletsianos (Ed.), *Emerging Technologies in Distance Education* (pp. 109–128). Edmonton, AB: Athabasca University Press.

Cuban, L. (2004). The Open Classroom. *Education Next, 2*(2), 68–71.

Cumming, J. J., & Maxwell, G. (1999). Contextualising Authentic Assessment. *Assessment in Education: Principles, Policies and Practices, 6*(2), 177–194.

Dalsgaard, C. (2006). Social software: E-learning beyond learning management systems. *European Journal of Open, Distance, and E-Learning, 9*(2), 1–7.

D'Antoni, S. (2009). Open Educational Resources: reviewing initiatives and issues. *Open Learning: the Journal of Open and Distance Learning, 24*(1), 3–10. http://doi.org/10.1080/02680510802625443

Dearden, A., & Finlay, J. (2006). Pattern Languages in HCI: A Critical Review. *Human-Computer Interaction, 21*(1), 49–102. http://doi.org/10.1207/s15327051hci2101_3

Derntl, M., & Motschnig-Pitrik, R. (2003). Towards a Pattern Language for Person-Centered E-Learning. In C. Crawford, N. Davis, J. Price, R. Weber, & D. A. Willis (Eds.), *Proceedings of Society for Information Technology Teacher Education International Conference* (pp. 2379–2382). Chesapeake, VA: AACE.

Dillenbourg, P. (2002). Over-scripting CSCL: The risks of blending collaborative learning with instructional design. In P. A. Kirschner (Ed.), *Three worlds of CSCL. Can we support CSCL* (pp. 61–91). Herleen: Open Universiteit Nederland.

Downes, S. (2005). E-learning 2.0. *eLearn Magazine, 2005*(10).

Duval, E., & Hodgins, W. (2004). Making Metadata go away: "Hiding everything but the benefits." In W. Jianzhong (Ed.), *Proceedings of the 2004 International Conference on Dublin Core and Metadata Applications: Metadata Across Languages and Cultures*. Shanghai: Dublin Core Metadata Initiative.

Duval, E., Verbert, K., & Klerkx, J. (2011). Towards an Open Learning Infrastructure for Open Educational Resources: Abundance as a Platform for Innovation. In C. Calude, G. Rozenberg, & A. Salomaa, *Lecture Notes in Computer Science* (Vol. 6570, pp. 144–156). Berlin / Heidelberg: Springer. http://doi.org/10.1007/978-3-642-19391-0_11

Efimova, L., & de Moor, A. (2005). Beyond personal webpublishing: An exploratory study of conversational blogging practices. In *Proceedings of the 38th Hawaii International Conference on System Sciences* (p. 107a). Los Alamitos, CA: IEEE. doi:10.1109/HICSS.2005.118

Ehn, P. (1992). Scandinavian Design: On Participation and Skill. In P. S. Adler & T. A. Winograd (Eds.), *Usability: Turning Technologies into Tools* (pp. 96–132). New York, NY: Oxford University Press.

Erickson, T. (2000). Lingua Francas for Design: Sacred Places and Pattern Languages. In D. Boyarski & W. A. Kellogg (Eds.), *Proceedings of the 3rd conference on Designing interactive systems processes, practices, methods, and techniques* (pp. 357–368). New York, NY: ACM Press. http://doi.org/10.1145/347642.347794

Fallman, D. (2008). The Interaction Design Research Triangle of Design Practice, Design Studies, and Design Exploration. *Design Issues, 24*(3), 4–18. http://doi.org/10.1162/desi.2008.24.3.4

Fallman, D., & Stolterman, E. (2010). Establishing criteria of rigour and relevance in interaction design research. *Digital Creativity, 21*(4), 265–272. http://doi.org/10.1080/14626268.2010.548869

Ficheman, I. K., & de Deus Lopes, R. (2008). Digital Learning Ecosystems: Authoring, Collaboration, Immersion and Mobility. In P. Díaz, Kinshuk, I. Aedo, & E. Mora (Eds.). *Proceedings of the Eighth IEEE International Conference on Advanced*

Learning Technologies (pp. 371–372). Los Alamitos: IEEE Computer Society. http://doi.org/10.1109/ICALT.2008.232

Fiedler, S., & Pata, K. (2009). Distributed learning environments and social software: In search for a framework of design. In S. Hatzipanagos & S. Warburton (Eds.), *Handbook of Research on Social Software and Developing Community Ontologies* (pp. 145–158). Hershey: IGI Global.

Fini, A., Formiconi, A., Giorni, A., Pirruccello, N. S., Spadavecchia, E., & Zibordi, E. (2008). IntroOpenEd 2007: an experience on Open Education by a virtual community of teachers. *Journal of e-Learning and Knowledge Society, 4*(1), 231–239.

Fini, A. (2009). The Technological Dimension of a Massive Open Online Course: The Case of the CCK08 Course Tools. *International Review of Research in Open and Distance Learning, 10*(5).

Friesen, N. (2004). Three Objections to Learning Objects and E-learning Standards. In R. McGreal (Ed.), *Online education using learning objects* (pp. 59–70). London: Routledge.

Fuster Morell, M. (2011). An Introductory Historical Contextualization of Online Creation Communities for the Building of Digital Commons: The Emergence of a Free Culture Movement. In S. Hellmann, P. Frischmuth, S. Auer, & D. Dietrich (Eds.), *OKCon 2011 Open Knowledge Conference. Proceedings of the 6th Open Knowledge Conference. Berlin, Germany, June 30 & July 1, 2011*. Aachen: CEUR-WS.

Gamma, E., Helm, R., Johnson, R., & Vlissides, J. (1994). *Design Patterns: Elements of Reusable Object-Oriented Software*. Boston, MA: Addison-Wesley.

Geser, G. (Ed.). (2007). *Open Educational Practices and Resources: OLCOS Roadmap 2012*. Salzburg: OLCOS Project.

Gibbons, A. S. (2010). A Contextual Framework for Identifying Instructional Design Patterns. In P. Goodyear & S. Retalis (Eds.), *Technology-Enhanced Learning: Design Patterns and Pattern Languages* (pp. 29–47). Rotterdam: Sense Publishers.

Gibbons, A. S. (2014). *An Architectural Approach to Instructional Design*. NewYork, NY: Routledge.

Goktas, Y., & Demirel, T. (2012). Blog-enhanced ICT courses: Examining their effects on prospective teachers' ICT competencies and perceptions. *Computers & Education, 58*(3), 908–917. http://doi.org/10.1016/j.compedu.2011.11.004

Goldberg, M. W. (1997). WebCT and first year; student reaction to and use of a Web-based resource in first year computer science. In *Proceedings of the 2nd conference on Integrating technology into computer science education (ITiCSE '97)*, pp. 127–129. New York, NY: ACM Press. http://doi.org/10.1145/268819.268856

Goodyear, P., Avgeriou, P., Baggetun, R., Bartoluzzi, S., Retalis, S., Ronteltap, F., & Rusman, E. (2004). *Towards a Pattern Language for Networked Learning*. Paper presented at the Networked Learning Conference 2004, Lancaster. Retrieved from http://www.networkedlearningconference.org.uk/past/nlc2004/proceedings/individual_papers/goodyear_et_al.htm

Goodyear, P. (2005). Educational design and networked learning: Patterns, pattern languages and design practice. *Australasian Journal of Educational Technology, 21*(1), 82–101.

Gulikers, J. T. M., Bastiaens, T. J., & Kirschner, P. A. (2004). A Five-Dimensional Framework for Authentic Assessment. *Educational Technology Research & Development, 52*(3), 67–86.

Gurell, S. (2008). *Open Educational Resources Handbook for Educators Version 1.0*. Logan: Center for Open and Sustainable Learning.

Gütl, C., & Chang, V. (2008). Ecosystem-based Theoretical Models for Learning in Environments of the 21st Century. *International Journal of Emerging Technologies in Learning, 3*(3), 50–60. http://doi.org/10.3991/ijet.v3i1.742

Harasim, L. (2000). Shift happens: Online education as a new paradigm in learning. *The Internet and Higher Education, 3*(1–2), 41–61. http://doi.org/10.1016/S1096-7516(00)00032-4

Hart, M. (1992). *The History and Philosophy of Project Gutenberg*. Retrieved from https://www.gutenberg.org/wiki/Gutenberg:The_History_and_Philosophy_of_Project_Gutenberg_by_Michael_Hart

Hatzipanagos, S. (2015). What do MOOCs contribute to the debate on learning design of online courses? *eLearning Papers*, 42, 1–10.

Haug, S., Wodzicki, K., Cress, U., & Moskaliuk, J. (2014). Self-Regulated Learning in MOOCs: Do Open Badges and Certificates of Attendance Motivate Learners to Invest More? In U. Cress & C. D. Kloos (Eds.), *Proceedings of the European MOOC Stakeholder Summit 2014* (pp. 66–72). P.A.U. Education.

Hilton, J., III, Wiley, D., Stein, J., & Johnson, A. (2010). The Four R's of Openness and ALMS Analysis: Frameworks for Open Educational Resources. *Open Learning: the Journal of Open, Distance and E-Learning, 25*(1), 37–44. http://doi.org/10.1080/02680510903482132

Himanen, P. (2001). *The Hacker Ethic and the Spirit of the Information Age*. New York, NY: Random House.

Howe, J. (2006). The Rise of Crowdsourcing. *Wired Magazine, 14*(6). Retrieved from http://archive.wired.com/wired/archive/14.06/crowds_pr.html

Hylén, J. (2008, August). Why Give Knowledge Away for Free? The Case for Open Educational Resources. *Open Source Business Resource*, 15–20.

Iiyoshi, T., & Kumar, M. S. V. (2008). Introduction: An Invitation to Open Up the Future of Education. In T. Iiyoshi, & M. S. V. Kumar (Eds.), *Opening Up Education: The Collective Advancement of Education through Open Technology, Open Content, and Open Knowledge* (pp. 1–10). Cambridge, MA: The MIT Press.

Illich, I. (2011). *Deschooling Society*. London: Marion Boyars. (Original work published 1971)

ISTE. (2008). *ISTE NETS for Teachers 2008*. Retrieved from http://www.iste.org/standards/standards-for-teachers/nets-for-teachers-2008

Johnson, M., & Liber, O. (2008). The Personal Learning Environment and the human condition: from theory to teaching practice. *Interactive Learning Environments, 16*(1), 3–15.

Jones, D. T. (2011). *An Information Systems Design Theory for E-learning*. Canberra: Australian National University.

Jovanovic, J., & Devedzic, V. (2015). Open Badges: Novel Means to Motivate, Scaffold and Recognize Learning. *Technology, Knowledge and Learning, 20*(1), 115–122. http://doi.org/10.1007/s10758-014-9232-6

Kay, A., & Goldberg, A. (1977). Personal Dynamic Media. *Computer, 10*(3), 31–41. http://doi.org/10.1109/C-M.1977.217672

Keats, D. (2006). Implications of the NonCommercial (NC) Restriction for Educational Content. *The African Journal of Information and Communication*, 7, 74–80.

Kikkas, K., Laanpere, M., & Põldoja, H. (2011). Open Courses: The Next big Thing in eLearning. In A. Rospigliosi (Ed.), *Proceedings of the 10th European Conference on e-Learning* (pp. 370–376). Reading: Academic Publishing Limited.

Kim, H. N. (2008). The phenomenon of blogs and theoretical model of blog use in educational contexts. *Computers & Education, 51*(3), 1342–1352.

Klamma, R., Chatti, M. A., Duval, E., Hummel, H., Hvannberg, E. T., Kravcik, M., et al. (2007). Social Software for Life-long Learning. *Educational Technology & Society, 10*(3), 72–83.

Kop, R., Fournier, H., & Mak, J. S. F. (2011). A Pedagogy of Abundance or a Pedagogy to Support Human Beings? Participant Support on Massive Open Online Courses. *The International Review of Research in Open and Distance Learning, 12*(7), 74–93.

Koppe, C., Holwerda, R., Tijsma, L., van Diepen, N., van Turnhout, K., & Bakker, R. (2015). Patterns for Using Top-level MOOCs in a Regular University. *eLearning Papers*, 42, 1–7.

Koskinen, I., Zimmerman, J., Binder, T., Redström, J., & Wensveen, S. (2011). *Design Research Through Practice: From the Lab, Field, and Showroom*. Waltham, MA: Morgan Kaufmann.

Kozinska, K. A. (2013). *Supporting lifelong learning with Open Educational Resources (OER) among diverse users: motivations for and approaches to learning with different OER* (Doctoral dissertation). The Open University. Retrieved from http://oro.open.ac.uk/id/eprint/40290

Laanpere, M., Põldoja, H., Kikkas, K. (2004). The Second Thoughts about Pedagogical Neutrality of LMS's. In Kinshuk, C. K. Looi, E. Sutinen, D. Sampson, I. Aedo, L. Uden, & E. Kähkonen (Eds.), *The 4th IEEE International Conference on Advanced Learning Technologies. Joensuu, Finland. 30 August – 1 September 2004* (pp. 807–809). Los Alamitos: IEEE Computer Society.

Laanpere, M., Pata, K., Normak, P., & Põldoja, H. (2012). Pedagogy-Driven Design of Digital Learning Ecosystems: The Case Study of Dippler. In E. Popescu, Q. Li, R. Klamma, H. Leung, & M. Specht (Eds.), *Lecture Notes in Computer Science: Vol 7558. Advances in Web-Based Learning – ICWL 2012* (pp. 307–317). Berlin: Springer. http://dx.doi.org/10.1007/978-3-642-33642-3_33

Laanpere, M., Põldoja, H., & Normak, P. (2013). Designing Dippler — A Next-Generation TEL System. In T. Ley, M. Ruohonen, M. Laanpere, & A. Tatnall (Eds.), *Open and Social Technologies for Networked Learning* (Vol. 395, pp. 91–100). Berlin: Springer. doi:10.1007/978-3-642-37285-8_10

Lackner, E., Ebner, M., & Khalil, M. (2015). MOOCs as granular systems: design patterns to foster participant activity. *eLearning Papers*, 42, 1–10.

Leinonen, T., Kligyte, G., Toikkanen, T., Pietarila, J., & Dean, P. (2003). Learning with Collaborative Software - A guide to Fle3. Helsinki: University of Art and Design Helsinki.

Leinonen, T., Toikkanen, T., & Silfvast, K. (2008). Software as Hypothesis: Research-Based Design Methodology. In *Proceedings of the Tenth Anniversary Conference on Participatory Design 2008* (pp. 61–70). Indianapolis, IN: Indiana University.

Leinonen, T., Vadén, T., & Suoranta, J. (2009). Learning in and with an open wiki project: Wikiversity's potential in global capacity building. *First Monday, 14*(2). Retrieved from http://firstmonday.org/htbin/cgiwrap/bin/ojs/index.php/fm/article/view/2252/2093

Leinonen, T. (2010). *Designing Learning Tools: Methodological Insights*. Helsinki: Aalto University School of Art and Design.

Lesko, I. (2013). The use and production of OER & OCW in teaching in South African higher education institutions. *Open Praxis, 5*(2), 103–121. http://doi.org/10.5944/openpraxis.5.2.52

Lin, Y.-W. (2007). Hacker Culture and the FLOSS Innovation. In K. St. Amant & B. Still (Eds.), *Handbook of Research on Open Source Software: Technological, Economic, and Social Perspectives* (pp. 34–46). Hershey, PA: IGI Global.

Littlejohn, A., & Milligan, C. (2015). Designing MOOCs for professional learners: Tools and patterns to encourage self-regulated learning. *eLearning Papers*, 42, 1–10.

Liu, T.-C. (2011). *Open Education and the Creative Economy: Global Perspectives and Comparative Analysis* (Doctoral dissertation). University of Illinois at Urbana-Champaign, Urbana, IL. Retrieved from http://hdl.handle.net/2142/29677

Liyanagunawardena, T. R., Adams, A. A., & Williams, S. A. (2013). MOOCs: A Systematic Study of the Published Literature 2008-2012. *The International Review of Research in Open and Distance Learning, 14*(3), 202–227.

Liyanagunawardena, T. R., Kennedy, E., & Cuffe, P. (2015). Design patterns for promoting peer interaction in discussion forums in MOOCs. *eLearning Papers*, 42, 1–16.

Löwgren, J., & Stolterman, E. (2007). *Thoughtful Interaction Design: A Design Perspective on Information Technology*. Cambridge, MA: The MIT Press.

Mackintosh, W. (2012). Opening Education in New Zealand: A Snapshot of a Rapidly Evolving OER Ecosystem. In J. Glennie, K. Harley, N. Butcher, & T. van Wyk (Eds.), *Open Educational Resources and Change in Higher Education: Reflections from Practice* (pp. 263–281). Vancouver: Commonwealth of Learning.

Malone, T. W., & Crowston, K. (1994). The Interdisciplinary Study of Coordination. *ACM Computing Surveys, 26*(1), 87–119.

Matsuo, Y., & Yamamoto, H. (2009). Community Gravity: Measuring Bidirectional Effects by Trust and Rating on Online Social Networks. In *WWW '09: Proceedings of the 18th international conference on World wide web* (pp. 751–760). New York, NY: ACM Press. http://doi.org/10.1145/1526709.1526810

McAndrew, P., & Farrow, R. (2013). The Ecology of Sharing: Synthesizing OER Research. In *Proceedings of OER13: Creating a Virtuous Circle*.

McAuley, A., Stewart, B., Siemens, G., & Cormier, D. (2010). *The MOOC Model for Digital Practice*. Retrieved July 5, 2015, from https://oerknowledgecloud.org/sites/oerknowledgecloud.org/files/MOOC_Final.pdf

McLoughlin, C. & Lee, M. J.W. (2007). Social software and participatory learning: Pedagogical choices with technology affordances in the Web 2.0 era. In R. J. Atkinson, C. McBeath, S. K. A. Soong, C. & Cheers (Eds.), *ICT: Providing choices for learners and learning*. *Proceedings ascilite Singapore 2007* (pp. 664–675). Singapore: Nanyang Technological University.

Meiszner, A. (2010). *The Emergence of Free / Open Courses: Lessons from the Open Source Movement* (Unpublished doctoral dissertation). The Open University.

Meiszner, A., & Papadopoulos, P. (2012). *Open Education Ecosystems, learning analytics and supportive software system framework*. Retrieved from http://www.scribd.com/doc/95345021/Open-Education-Ecosystems-learning-analytics-and-supportive-software-system-framework

Merrill, D. C., Reiser, B. J., Ranney, M., & Trafton, J. G. (1992). Effective Tutoring Techniques: A Comparison of Human Tutors and Intelligent Tutoring Systems. *Journal of the Learning Sciences, 2*(3), 277–305. http://doi.org/10.1207/s15327809jls0203_2

Miller, G. E. (1990). The assessment of clinical skills/competence/performance. *Academic Medicine, 65*(9), S63–S67.

Molnar, A. (1997, June). Computers in Education: A Brief History. *The Journal*. Retrieved from http://thejournal.com/Articles/1997/06/01/Computers-in-Education-A-Brief-History.aspx

Mor, Y., & Warburton, S. (2015). Practical Patterns for Active and Collaborative MOOCs: Checkpoints, FishBowl and See Do Share. *eLearning Papers*, 42, 1–9.

Mott, J., & Wiley, D. (2009). Open For Learning: The CMS and the Open Learning Network. *In Education, 15*(2), 3–22.

Möller, E. (2007). *The Case for Free Use: Reasons Not to Use a Creative Commons -NC License*. Retrieved from http://freedomdefined.org/Licenses/NC

Muukkonen, H., Hakkarainen, K., & Lakkala, M. (2004). Computer-Mediated Progressive Inquiry in Higher Education. In T. S. Roberts (Ed.), *Online Collaborative Learning: Theory and Practice* (pp. 28–53). Hershey, PA: Information Science Publishing.

Nelson, H. G., & Stolterman, E. (2012). *The Design Way: Intentional Change in an Unpredictable World* (2nd ed.). Cambridge, MA: The MIT Press.

Nicholson, P. (2007). A History of E-Learning. In B. Fernández-Manjón, J. M. Sánchez-Pérez, J. A. Gómez-Pulido, M. A. Vega-Rodríguez, & J. Bravo-Rodríguez, *Computers and Education* (pp. 1–11). Dordrecht: Springer. http://doi.org/10.1007/978-1-4020-4914-9_1

Nilsson, M., Johnston, P., Naeve, A., & Powell, A. (2007). The Future of Learning Object Metadata Interoperability. In K. Harman & A. Koohang (Eds.), *Learning Objects: Standards, Metadata, Repositories, and LCMS* (pp. 255–313). Santa Rosa, CA: Informing Science Press.

Novak, J. D. (2010). *Learning, Creating, and Using Knowledge: Concept Maps as Facilitative Tools in Schools and Corporations* (2nd ed.). New York, NY: Routledge.

OECD. (2007). *Giving Knowledge for Free: The Emergence of Open Educational Resources*. Paris: OECD Publishing. Retrieved from http://www.oecd.org/dataoecd/35/7/38654317.pdf

Ondercin, D. J. (2011). *The Economics of Openness in Higher Education* (Doctoral dissertation). University of Illinois at Urbana-Champaign, Urbana, IL. Retrieved from http://hdl.handle.net/2142/29426

Orme, N. (1978). The Guild of Kalendars, Bristol. *Transactions of the Bristol and Gloucestershire Archaeological Society, 96*, 32–52. Retrieved from http://www2.glos.ac.uk/bgas/tbgas/v096/bg096032.pdf

O'Reilly, T. (2005, September 30). What Is Web 2.0: Design Patterns and Business Models for the Next Generation of Software. Retrieved from http://oreilly.com/web2/archive/what-is-web-20.html

Paavola, S., Lipponen, L., & Hakkarainen, K. (2004). Models of Innovative Knowledge Communities and Three Metaphors of Learning. *Review of Educational Research, 74*(4), 557–576. http://doi.org/10.3102/00346543074004557

Papazoglou, M. P. (2003). Service-Oriented Computing: Concepts, Characteristics and Directions. In T. Catarci, M. Mecella, J. Mylopoulos, & M. E. Orlowska (Eds.), *Proceedings of the Fourth International Conference on Web Information Systems Engineering* (pp. 3–12). Los Alamitos: IEEE Computer Society. http://doi.org/10.1109/WISE.2003.1254461

Papert, S. (1972). Teaching Children Thinking. *Innovations in Education & Training International, 9*(5), 245–255. http://doi.org/10.1080/1355800720090503

Park, I., & Hannafin, M. J. (1993). Empirically-based guidelines for the design of interactive multimedia. *Educational Technology Research & Development, 41*(3), 63–85. http://doi.org/10.1007/BF02297358

Parrish, P. E. (2004). The Trouble with Learning Objects. *Educational Technology Research & Development, 52*(1), 49–67.

Pata, K., & Bardone, E. (2014). Promoting Distributed Cognition at MOOC Ecosystems. In P. Zaphiris & A. Ioannou (Eds.), *Lecture Notes in Computer Science: Vol. 8523. New Horizons in Web Based Learning* (pp. 204–215). Cham: Springer. http://doi.org/10.1007/978-3-319-07482-5_20

Peña-López, I. (2013). Heavy switchers in translearning: from formal teaching to ubiquitous learning. *On the Horizon, 21*(2), 127–137. http://doi.org/10.1108/10748121311323021

Petrides, L., Nguyen, L., Jimes, C., & Karaglani, A. (2008). Open educational resources: inquiring into author use and reuse. *International Journal of Technology Enhanced Learning, 1*(1/2), 98–20. http://doi.org/10.1504/IJTEL.2008.020233

Porter, D. A. (2013). *Exploring the Practices of Educators Using Open Educational Resources (OER) in the British Columbia Higher Education System* (Doctoral dissertation). Simon Fraser University. Retrieved from http://summit.sfu.ca/item/13663

Põldoja, H. & Laanpere, M. (2009). Conceptual Design of EduFeedr — an Educationally Enhanced Mash-up Tool for Agora Courses. In F. Wild, M. Kalz, M. Palmér, & D. Müller (Eds.), *Mash-Up Personal Learning Environments. Proceedings of the 2nd Workshop MUPPLE'09, Nice, France, September 29, 2009* (pp. 98–101). Aachen: CEUR-WS.

Põldoja, H. (2010). EduFeedr: following and supporting learners in open blog-based courses. In *Open ED 2010 Proceedings* (pp. 399–407). Barcelona: UOC, OU, BYU.

Põldoja, H., Savitski, P., & Laanpere, M. (2010). Aggregating Student Blogs with EduFeedr. Lessons Learned from First Tryouts. In F. Wild, M. Kalz, & M. Palmér (Eds.), *Mashup-Personal Learning Environments. Proceedings of the 3rd Workshop MUPPLE'10. Barcelona, Spain. 29 September 2010*. Aachen: CEUR-WS.

Põldoja, H., & Laanpere, M. (2014). Exploring the Potential of Open Badges in Blog-Based University Courses. In Y. Cao, T. Väljataga, J. K. T. Tang, H. Leung, & M. Laanpere (Eds.), *Lecture Notes in Computer Science: Vol. 8699. New Horizons in Web Based Learning* (pp. 172–178). Cham: Springer. http://doi.org/10.1007/978-3-319-13296-9_19

Põldoja, H., Väljataga, T., Laanpere, M., & Tammets, K. (2014). Web-based self- and peer-assessment of teachers' digital competencies. *World Wide Web, 17*(2), 255–269. http://doi.org/10.1007/s11280-012-0176-2

Põldoja, H., Duval, E., & Leinonen, T. (2016). Design and evaluation of an online tool for open learning with blogs. *Australasian Journal of Educational Technology, 32*(2), 64–81. http://dx.doi.org/10.14742/ajet.2450

Pournaras, E., & Miah, S. J. (2012). From metaphor towards paradigm - A computing roadmap of digital ecosystems. In *Proceedings of the 2012 6th IEEE International Conference on Digital Ecosystems and Technologies (DEST) - Complex Environment Engineering*. IEEE. http://doi.org/10.1109/DEST.2012.6227904

Preece, J., Rogers, Y., & Sharp, H. (2007). *Interaction Design: Beyond Human-Computer Interaction* (2nd ed.). Chichester: John Wiley & Sons.

Renya, J. (2011). Digital Teaching and Learning Ecosystem (DTLE): A Theoretical Approach for Online Learning Environments. In G. Williams, P. Statham, N. Brown & B. Cleland (Eds.), *Changing Demands, Changing Directions. Proceedings ascilite Hobart 2011* (pp. 1083–1088). Hobart: University of Tasmania.

Retalis, S., Georgiakakis, P., & Dimitriadis, Y. (2007). Eliciting design patterns for e-learning systems. *Computer Science Education, 16*(2), 105–118. http://doi.org/10.1080/08993400600773323

Rittel, H. W. J., & Webber, M. M. (1973). Dilemmas in a General Theory of Planning. *Policy Sciences, 4*(2), 155–169. http://doi.org/10.1007/BF01405730

Rodriguez, C. O. (2012). MOOCs and the AI-Stanford like Courses: two successful and distinct course formats for massive open online courses. *European Journal of Open, Distance, and E-Learning, 15*(1).

Rodriguez, O. (2013). The concept of openness behind c and x-MOOCs (Massive Open Online Courses). *Open Praxis, 5*(1), 67–73.

Rohse, S., & Anderson, T. (2006). Design patterns for complex learning. *Journal of Learning Design, 1*(3), 1–10. http://doi.org/10.5204/jld.v1i3.35

Rubens, W., Emans, B., Leinonen, T., Skarmeta, A. G., & Simons, R.-J. (2005). Design of web-based collaborative learning environments. Translating the pedagogical learning principles to human computer interface. *Computers & Education, 45*(3), 276–294. http://doi.org/10.1016/j.compedu.2005.04.008

Salinesi, C. (2004). Authoring Use Cases. In I. F. Alexander & N. Maiden (Eds.), *Scenarios, Stories, Use Cases: Through the Systems Development Life-Cycle* (pp. 141–160). Chichester: John Wiley & Sons.

Santos, J. L., Charleer, S., Parra, G., Klerkx, J., Duval, E., & Verbert, K. (2013). Evaluating the Use of Open Badges in an Open Learning Environment. In D. Hernández-Leo, T. Ley, & R. Klamma (Eds.), *Lecture Notes in Computer Science: Vol. 8095. Scaling up Learning for Sustained Impact* (pp. 314–327). Berlin: Springer. http://doi.org/10.1007/978-3-642-40814-4_25

Schaffert, S., & Geser, G. (2008). Open Educational Resources and Practices. *eLearning Papers*, 7.

Schmidt, J. P., Geith, C., Håklev, S., & Thierstein, J. (2009). Peer-To-Peer Recognition of Learning in Open Education. *International Review of Research in Open and Distance Learning, 10*(5), 1–16.

Schmidt, J. P., & Surman, M. (2007). *Open sourcing education: Learning and wisdom from iSummit 2007.* Retrieved from http://archive.icommons.org/resources/open-sourcing-education-learning-and-wisdom-from-isummit-2007

Schön, D. A. (1991). *The Reflective Practitioner: How Professionals Think in Action*. Farnham: Ashgate.

Sharples, M., Taylor, J., & Vavoula, G. (2005). *Towards a Theory of Mobile Learning*. Paper presented at the mLearn 2005: 4th World conference on mLearning, Cape Town. Retrieved from http://www.mlearn.org/mlearn2005/CD/papers/Sharples-%20Theory%20of%20Mobile.pdf

Shirky, C. (2003, May 20). Social Software: A New Generation of Tools. *Release 1.0, 21*(5), 1–30.

Siemens, G. (2012). Learning Analytics: Envisioning a Research Discipline and a Domain of Practice. In S. B. Shum, D. Gasevic, & R. Ferguson (Eds.), *Proceedings of the 2nd International Conference on Learning Analytics and Knowledge* (pp. 4–8). New York, NY: ACM.

Sim, J. W. S., & Hew, K. F. (2010). The use of weblogs in higher education settings: A review of empirical research. *Educational Research Review, 5*(2), 151–163.

Sims, R. (1988). Futures for computer-based training: Developing the learner-computer interface. *Australian Journal of Educational Technology, 4*(2), 123–136.

Sloane, A. (1997). Learning with the web: Experience of using the World Wide Web in a learning environment. *Computers & Education, 28*(4), 207–212. http://doi.org/10.1016/S0360-1315(97)00017-1

Snyder, C. (2003). *Paper Prototyping: The Fast and Easy Way to Design and Refine User Interfaces*. San Francisco, CA: Morgan Kaufmann.

Spoelstra, H. (2015). *Collaborations in Open Learning Environments: Team Formation for Project-based Learning* (Doctoral dissertation). Open University of the Netherlands, Heerlen. Retrieved from http://hdl.handle.net/1820/6024

Stahl, G. (2000). A Model of Collaborative Knowledge-Building. In B. J. Fishman & S. F. O'Connor-Divelbiss (Eds.), *International Conference of the Learning Sciences: Facing the Challenges of Complex Real-world Settings* (pp. 70–77). Mahwah, NJ: Psychology Press.

structure, n. (2014). In *OED Online* (3rd ed.). Retrieved from http://www.oed.com/view/Entry/191895

Suen, H. K. (2014). Peer Assessment for Massive Open Online Courses (MOOCs). *The International Review of Research in Open and Distance Learning, 15*(3), 312–327.

Sumner, J. (2000). Serving the System: A critical history of distance education. *Open Learning: the Journal of Open and Distance Learning, 15*(3), 267–285. http://doi.org/10.1080/713688409

Sun, J., Flores, J., & Tanguma, J. (2012). E-Textbooks and Students' Learning Experiences. *Decision Sciences Journal of Innovative Education, 10*(1), 63–77. http://doi.org/10.1111/j.1540-4609.2011.00329.x

Suppes, P. (1966). The Uses of Computers in Education. *Scientific American, 215*(3), 206–220.

Suppes, P. (1971). *Computer-assisted Instruction at Stanford* (Report No. 174). Retrieved from Stanford University website: http://suppes-corpus.stanford.edu/techreports/IMSSS_174.pdf

Toiviainen, T. (1995). A comparative study of Nordic residential folk high schools and the Highlander Folk School. *Convergence, 28*(1), 5–17.

Tuomi, I. (2006). *Open Educational Resources: What they are and why do they matter*. Retrieved from http://www.meaningprocessing.com/personalPages/tuomi/articles/OpenEducationalResources_OECDreport.pdf

Uden, L., Wangsa, I. T., & Damiani, E. (2007). The future of E-learning: E-learning ecosystem. In E. Chang & F. K. Hussain (Eds.), *2007 Inaugural IEEE International Conference on Digital Ecosystems and Technologies* (pp. 113–117). IEEE. http://doi.org/10.1109/ DEST.2007.371955

UNESCO. (2002). *Forum on the Impact of Open Courseware for Higher Education in Developing Countries* (Report No. CI-2002/CONF.803/CLD.1). Paris: UNESCO. Retrieved from http://unesdoc.unesco.org/images/0012/001285/128515e.pdf

UNESCO. (2012). *2012 Paris OER Declaration*. Paris: UNESCO. Retrieved from http://www.unesco.org/new/fileadmin/MULTIMEDIA/HQ/CI/CI/pdf/Events/English_Paris_OER_Declaration.pdf

Väljataga, T., & Laanpere, M. (2010). Learner control and personal learning environment: a challenge for instructional design. *Interactive Learning Environments, 18*(3), 277–291.

Väljataga, T., Põldoja, H., Laanpere, M. (2011). Open Online Courses: Responding to Design Challenges. In H. Ruokamo, M. Eriksson, L. Pekkala, & H. Vuojärvi (Eds.), *Proceedings of the 4th International Network-Based Education 2011 Conference The Social Media in the Middle of Nowhere* (pp. 68-75). Rovaniemi: University of Lapland.

van Duyne, D. K., Landay, J. A., & Hong, J. I. (2007). *The Design of Sites: Patterns for Creating Winning Web Sites* (2nd ed.). Upper Saddle River, NJ: Prentice Hall.

van Welie, M., & van der Veer, G. C. (2003). Pattern Languages in Interaction Design: Structure and Organization. In M. Rauterberg, M. Menozzi, & J. Wesson (Eds.), *Human-Computer Interaction – INTERACT '03* (pp. 527–534). Amsterdam: IOS Press.

Weinberger, D. (2002). *Small Pieces Loosely Joined: A Unified Theory of the Web.* Cambridge, MA: Basic Books.

Weippl, E. R., & Ebner, M. (2008). Security & Privacy Challenges in E-Learning 2.0. In C. J. Bonk, M. M. Lee, & T. Reynolds, *Proceedings of World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education 2008* (pp. 4001–4007). Chesapeake, VA: AACE.

Weller, M. (2010). Big and Little OER. In *Open ED 2010 Proceedings* (pp. 583–591). Barcelona: UOC, OU, BYU.

Welsh, E. T., Wanberg, C. R., Brown, K. G., & Simmering, M. J. (2003). E-learning: emerging uses, empirical results and future directions. *International Journal of Training and Development, 7*(4), 245–258. http://doi.org/10.1046/j.1360-3736.2003.00184.x

Wild, F., Lefrere, P., Scott, P., & Naeve, A. (2013). The Grand Challenges. In F. Wild, P. Lefrere, & P. Scott (Eds.), *Technology and Knowledge in the Future: a Roadmap* (pp. 17–28). Milton Keynes: The Open University.

Wiley, D., & Gurrell, S. (2009). A decade of development…. *Open Learning: the Journal of Open and Distance Learning, 24*(1), 11–21. http://doi.org/10.1080/02680510802627746

Wiley, D. (2014, March 5). *The Access Compromise and the 5th R* [Web log message]. Retrieved from http://opencontent.org/blog/archives/3221

Wiley, D. (2015). The MOOC Misstep and the Open Education Infrastructure. In C. J. Bonk, M. M. Lee, T. C. Reeves, & T. H. Reynolds (Eds.), *MOOCs and Open Education Around the World* (pp. 3–11). New York, NY: Routledge.

The William and Flora Hewlett Foundation. (n.d.). *Open Educational Resources*. Retrieved June 10, 2015, from http://www.hewlett.org/programs/education/open-educational-resources

Williams, J. B., & Jacobs, J. (2004). Exploring the use of blogs as learning spaces in the higher education sector. *Australasian Journal of Educational Technology, 20*(2), 232–247.

Wilson, S., Liber, O., Johnson, M., Beauvoir, P., Sharples, P., & Milligan, C. (2007). Personal Learning Environments: Challenging the dominant design of educational systems. *Journal of E-Learning and Knowledge Society, 3*(2), 27–38.

Yee, J. S. R. (2010). Methodological Innovation in Practice-Based Design Doctorates. *Journal of Research Practice, 6*(2), 1–23.

Yin, R. K. (2014). *Case Study Research: Design and Methods* (5th ed.). Los Angeles, CA: Sage.

Yuan, L., Robertson, R. J., Campbell, L. M., & Pegler, C. (2010). Examining the sustainability issues in UKOER projects: Developing a sustainable OER ecosystem in HE. In *Open ED 2010 Proceedings* (pp. 613–625). Barcelona: UOC, OU, BYU.

Publication 1

Põldoja, H., Leinonen, T., Väljataga, T., Ellonen, A., & Priha, M. (2006). Progressive Inquiry Learning Object Templates (PILOT). *International Journal on E-Learning, 5*(1), 103–111.

International Jl. on E-Learning (2006) **5***(1),* 103-111

Progressive Inquiry Learning Object Templates (PILOT)

HANS PÕLDOJA, TEEMU LEINONEN
University of Art and Design Helsinki, Finland
hans.poldoja@uiah.fi
teemu.leinonen@uiah.fi

TERJE VÄLJATAGA
Tampere University of Technology, Finland
terje.valjataga@tut.fi

ANTTI ELLONEN, MARJO PRIHA
Uusimaa Regional Environmental Centre, Finland
antti.ellonen@ymparisto.fi
marjo.priha@ymparisto.fi

In most cases digital learning objects are used for individual learning (reading, looking, playing, quizzes) or by teachers in their class-room or online teaching (presentations). In PILOT project we argue that learning objects should be designed and presented in a special way in order to promote truly social constructivist learning. The project is based on the concept of progressive inquiry learning object templates (PILOTs). These learning objects support progressive inquiry knowledge building process in computer and database supported Knowledge Building environments, found for instance in Fle3 and IVA virtual learning environments. Design research methods such as participatory design and scenario-based design are used in the project to generate distributable and reusable PILOTs. The developed learning objects will be tested and evaluated by schools, teachers, and their pupils.

PEDAGOGICAL FOUNDATIONS

In most cases learning objects are used for individual learning (reading, looking, playing, quizzes) or by teachers in their teaching (presentations).

For example in ARIADNE knowledge pool system, the majority of learning objects are narrative texts, excercises, hypertexts, and slides (Najjar, Ternier, & Duval, 2003). At the time of writing only 1.4 % of more than 4,400 existing learning objects in ARIADNE were described as project statements, which means that they are most likely based on constructivist pedagogy.

In UIAH Media Lab our views are based on the social constructivist theory that sees learning as the participation in social processes of knowledge construction. We have developed the Fle3 learning environment (see http://fle3.uiah.fi), which is designed for social constructivist learning. The environment contains three learning tools: *WebTop, Knowledge Building,* and *Jamming*. *WebTops* can be used for storing different items (files, links, notes). With the *Knowledge Building* tool groups can carry out knowledge building discussions to debate on the given context and build their own theories. Jamming tool is used for collaborative design and construction of digital artefacts (images, sound, etc.) (Leinonen, Kligyte, Toikkanen, Pietarila, & Dean, 2003). The tools originally created in Fle3 are present also in IVA learning management system (see http://www.htk.tlu.ee/iva/), which was developed based on Fle3 source code in Tallinn University (Laanpere, Põldoja, & Kikkas, 2004).

The main tool of Fle3 is *Knowledge Building*, where discussions can be carried out with different thinking type sets. These are sets of labels with associated instructions for structuring the discussion process towards a process that the thinking type set tries to support. The most commonly used thinking type set in Fle3 is progressive inquiry. In progressive inquiry students can choose the the proper knowledge type for their note from five knowledge types (Figure 1).

The progressive inquiry pedagogical model was developed in the department of psychology, at the University of Helsinki. It is a model of learning where students are encouraged to engage in the process of question and

Figure 1. Choosing the knowledge type in Fle3 Knowledge Building

explanation driven inquiry (Muukkonen, Hakkarainen, & Lakkala, 1999). As a method of teaching and learning this means that the pupils are encouraged to make their conceptions of the topics studied explicit, and then the study group works together to improve the presented ideas and explanation.

The conceptual framework of progressive inquiry is often presented (Muukkonen et al., 1999; Hakkarainen, Lonka, & Lipponen, 1999) as six steps that loosely follow each other. The steps are:

1. creating context,
2. engaging in question-driven inquiry,
3. generating one's own working theories,
4. critical evaluation of knowledge advancement,
5. searching new scientific information, and
6. engagement in deepening inquiry.

All six aspects of inquiry are shared with fellow inquirers. The aim of the process is accumulation and deepening of knowledge of all the pupils. As the students are encouraged to start the process with some open-ended research questions that are driving the inquiry, pupils may present with the help of their teacher questions that are suitable, challenging, and motivating for them.

THE DESIGN RESEARCH PROBLEMS

The use of Fle3 and IVA in classroom learning has shown that the environment would be easier for teachers to exploit if there are ready-made content packages that frame the context and give a starting point for the progressive inquiry process. The idea of the ready-made content is not to provide material that students should study in a traditional manner, but to open problems and questions that the students want to solve during the inquiry study process. The content should generate desire to present their own hypothesis on the topics and find out scientific information on them. This way the ready-made content may help teacher and pupils carry-out the first two steps of the progressive inquiry and give some hints to the third one.

The design problems of the research are:

- How is progressive inquiry supported with ready-made rich media content packages (LO's)?
- How should the ready-made rich media content package be?
- How is easy localization and reusability provided while retaining authentic context?
- What are the general features of the package?
- Would the package help teachers and pupils, who do not yet know the

progressive inquiry model very well to use it in their teaching and learning practice?

The design research is looking for answers to the questions by building up concepts and developing prototypes of a package. In the following section we will present the concept and the prototype developed.

DESIGN AND DEVELOPMENT OF PILOTS

Our concept is called progressive inquiry learning object templates (PILOTs). PILOTs are the ready-made content packages made to facilitate progressive inquiry learning inside virtual learning environment. The word *template* emphasizes the reusability (using, editing, modifying, and sharing) of learning objects. The teacher is able to change the learning object before starting the context. PILOTs can be seen as a metaphor for guiding the knowledge building process.

The aim of the PILOT project is to develop several content packages for use in secondary school level. The learning objects are developed in cooperation between UIAH Media Lab Learning Environments research group and the Uusimaa Regional Environment Centre on the topic of wetlands. The school subject where PILOTs is primarily planned to be studied is biology or geography, but can also be used in environmental education study projects that are integrating several school subjects. There is a plan to translate the example PILOTs from Finnish to Estonian and create an English masterfile for future localizations.

The design process was carried out by the principles of participatory design by thinking and discussing among the design team about the scenarios of the possible use of the PILOTs in a primary school education. Our context scenario is a concrete story of use. The strength of scenario-based design lies in it's ease and accessibility. It does not require any special knowledge to understand a scenario. Scenarios are easy to change, they evoke discussion, and raise various questions (Carroll, 2000). The scenario was shared among the design team members to reflect and clarify the concept (Figure 2).

The project is done in close cooperation with the existing learning technology standard development, which is important in the context of PILOTs: IEEE Learning Object Metadata standard, IMS Content Packaging, and IMS Learning Design specifications. The aim of the IMS Learning Design Specification is to prescribe various activities for learner and staff in a certain order. It can be seen as the lesson planning for e-learning. The description for the wetlands learning event was developed on IMS Learning Design Level A (IMS, 2003). It describes a six week learning event, in which the PILOTs are used (see Figure 3). IMS Learning Design is designed to work together with IMS Content Packaging, because Learning Design itself does

According to the national educational curriculum, the six-grade teacher is starting a course in her classroom on wetlands. The course should have a perspective of environmental conservation and lead student to understand what are the wetlands and why they are important. Teacher is an expert of progressive inquiry learning method and has been using Fle3 with her students for several years. She starts the planning of the course by searching from Internet ideas on how to organize the course with her students. With search engine she finds from the learning material database of the Finland's Environmental Administration a PILOTs with a title "wetlands". She looks for the description and realise that it could be a suitable for her needs. As the PILOTs is offered by the Environmental Administration she may trust that it is well designed and contains valid information. She downloads the PILOTs in her own computer and brings it to her Fle3. She takes a closer look of the content of the PILOTs inside Fle3, makes some minor editing to some ready-made research questions of the PILOTs. Now she is ready to use the PILOTs. She starts the course with her students.

Figure 2. Scenario of the use of PILOTs in a six-grade environmental education

not specify information about the content. The use of PILOTs as content packages has not been implemented yet in Fle3.

Based on the scenarios and learning design description we started to design the first prototype of PILOTs. The main content of PILOTs, the knowledge building context, were written in cooperation with environmental experts and pedagogy experts. The texts were refined in several iterations. Context has a title, short description, and a long description. When the contexts were ready, short scenarios were written to describe the multimedia part of PILOTs. It was expected that a teacher will shortly describe the topic before launching the PILOTs, therefore long description of the context was used as a voiceover text in the scenarios. The voiceover texts were divided into three or four parts. Important keywords from the voiceover text were highlighted and relevant photos selected for all the parts.

Technically multimedia part of PILOTs was implemented in Macromedia Flash 7. Flash was used for multimedia content because it is the most popular browser plug-in for rich media playback. Recent studies show that 98.0% of web users have Flash Player installed (Macromedia, 2004). According to the scenario the most important keywords from the voiceover text are displayed in the movie. It is possible to navigate between the different parts of the movie and see the timeline. At the end of the movie all the ready-made research questions are displayed on the screen (Figure 4).

The Wetlands
Introduction

The Wetlands is designed as a six-week progressive inquiry learning event (2 lessons in a week) for students at the age of 13-15.

The learning event has three main phases:

1. Finding out what is a wetland? ("Kosteikko - maan ja veden välissä")
2. Studying different kind of wetlands and their differences ("Suo siellä, kosteikko täällä")
3. Why wetlands are important? ("Kosteikossa kuhisee")

These three main phases are also the contexts in the Fle3 Knowledge Building.

The resources and facilities needed include:

- Content:
  - Aims and Objectives of the learning activity itself.
  - Short and full descriptions of the course contexts.
  - Ignition questions, which aim is to help to get the KB on the run
  - Multimedia PILOTs of the course contexts
- Tools:
  - Learning environment with Knowledge Building tool.
  - Image processing software
  - Pen and notebook
  - Microscope
  - Binoculars
  - Ph test kit
  - Rubber boots
  - Recording equipment
- Communications:
  - Small groups and classroom discussions
  - Knowledge building discourse
  - Presentations

PILOTs is the new type of learning object developed to introduce the topic and to encourage the Knowledge Building discussions.

The basic sequence of the learning event is:

1. Introduction to the wetland's topic
   a. Multimedia "teaser" about the wetlands in general
   b. Classroom discussion about the wetlands
   c. Introduction to progressive inquiry learning
   d. First progressive inquiry session in KB
2. Different types of wetlands
   a. Multimedia "teaser" about the wetlands in general
   b. Classroom discussion about the wetlands
   c. Introduction to progressive inquiry learning
   d. First progressive inquiry session in KB
3. The biodiversity of wetlands
   a. Multimedia "teaser" about the wetlands in general
   b. Classroom discussion about the wetlands
   c. Introduction to progressive inquiry learning
   d. First progressive inquiry session in KB

Figure 3. The IMS Learning Design description for wetlands learning event (Level A)

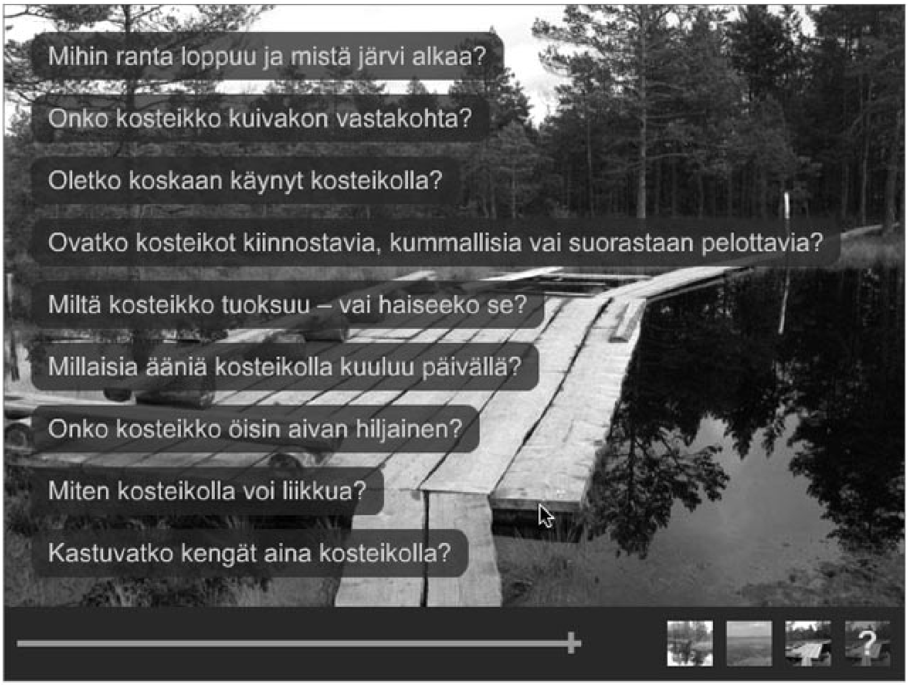


Figure 4. Research questions displayed at the end of the movie

In the first version, voiceover and images were linked to the main movie, which made it possible to start the playback as soon as the main movie was downloaded. The main drawback of this solution was impossibility to guarantee, that the voiceover text will be exactly synchronized with the keywords, which were displayed only for a short period of time. In the second version voiceover and images were included to the main file. Typical duration of the movie is around 2 minutes and size between 500...700 KB.

The PILOTs approach emphasizes the modularity, reusability, and distributability of learning object templates. With PILOTs teacher can build up a progressive inquiry course framework by bringing different kind of PILOTs to the one course. Currently this is possible by inserting the PILOTs text to Fle3 knowledge building context and adding a link to the Flash movie. Teachers can also save the PILOTs movie from the web, upload it to their Fle3 webtop and point the link in knowledge building to the webtop. It is also possible to make ready course frameworks, which already include context texts and movies. The administrator can export and import those courses in XML format, which is compatible with Educational Modelling Language. In the future we plan to change Fle3 Knowledge Building so, that it becomes possible to export/import individual PILOTs (both text and multimedia part) as content packages.

Editing, Localizing, and Reusing PILOTs

The main idea behind teaching is to offer students learning material in an appropriate context. The awareness of learning context in a learning situation is not a new idea, but researches rarely pay attention to the framework of learning contexts or activities and emphasize more on content, neglecting context (Afonso, 2002).

From a pedagogical point of view incompatible context proved to be a serious problem (Christiansen & Anderson, 2004). According to the instructional design, context is crucial to provide sense and structure to content (Afonso, 2002). Contextualized learning material helps students catch the meaning and deep understanding of the concept, procedure, information, or skill that learners are required to learn (Martin, 1998).

The PILOT model forestalls the critical issues in terms of contextualizing learning objects. Referred to the technology-based anchored instruction, PILOTs consists of a similar idea by setting up an authentic learning context. Anchored instruction was developed by the Cognition and Technology Group at Vanderbilt and stresses the importance of placing learning within a meaningful context (Bransford, 1990).

Learning objects with provided pedagogical context enable reuse of objects, as it also becomes possible for the teacher to modify the learning methods according to the other contextualized issues such as learner group, background, and so forth (Wilson, 2001).

PILOTs can be modified and edited according to the target group and objectives of the lesson by localizing the content and providing an appropriate learning context without needing to modify the original template of an object. Editing PILOTs does not mean that teachers have to know how to use Flash or other multimedia authoring tools. In most cases the teacher will edit only the text part of PILOTs. It must be seen as a template for the progressive inquiry context, not the ready-made learning object.

CONCLUSIONS

PILOT is currently work-in-progress. The first rich media content PILOTs have been developed and internally tested in the design team.

The development process has shown that participatory design and scenario-based design methods, which include experts from different fields is suitable for developing this kind of learning objects. The design research still requires evaluation and iteration of the first prototypes.

More research is needed on testing PILOTs with teachers. First, the research should look for teachers' ways of taking the PILOTs in use, ways of editing and improving them, and testing how the improvements could be shared among other teachers. Second, research should focus on the actual use of the PILOTs among the pupils. Do the pupils find it easier to adapt in the progressive inquiry process with PILOTs or do PILOTs actually lead students to a process that is no more progressive inquiry within their own framing of the topics under study. In this case learning process may end up being only simple gathering of information to find answers to the ready-made questions without deeper cognition and regulation of the groups' work.

The evaluation of PILOTs in school lessons was planned for Autumn 2005. Additional information and the rich media part of example PILOTs are available on the project homepage: http://fle3.uiah.fi/pilot/

References

Afonso, A. P. (2002). Models for the development of learning contexts: Managing learning and knowledge in virtual environments through learning communities. *Proceedings of the International Conference on Computers in Education,* (pp. 1504-1505), Auckland, New Zealand.

Bransford, J. (1990). Anchored instruction: Why we need it and how technology can help. In D. Nix & R. Spiro (Eds.), *Cognition, education, and multimedia.* Hillsdale, NJ: Lawrence Erlbaum.

Caroll, J.M. (2000). *Making use. Scenario-based design of human-computer interactions.* Cambridge, MA: The MIT Press.

Christiansen, J. A., & Anderson, T. (2004). Feasibility of course development based on learning objects: Research analysis of three case studies. *International Journal of Instructional Technology and Distance Learning.* Retrieved February 21, 2005, from http://www.itdl.org/Journal/Mar_04/article02.htm

Hakkarainen, K., Lonka, K., & Lipponen, L., (1999). *Tutkiva oppiminen.* Älykkään toiminnan rajat ja niiden ylittäminen. Porvoo: WSOY.

IMS (2003). *IMS learning design information model.* Retrieved January 20, 2005, from http://www.imsglobal.org/learningdesign/ldv1p0/imsld_infov1p0.html

Laanpere, M., Põldoja, H., & Kikkas, K. (2004, August). The second thoughts about pedagogical neutrality of LMSs. In *Proceedings of the 4th IEEE International Conference on Advanced Learning Technologies,* (pp.807-809). Joensuu, Finland. Los Alamitos, CA: IEEE.

Leinonen, T., Kligyte, G., Toikkanen, T., Pietarila, J., & Dean, P. (2003). *Learning with collaborative software - A guide to Fle3.* Helsinki, University of Art and Design Helsinki.

Macromedia (2004). *Macromedia flash player statistics.* Retrieved October 26, 2004, from http://www.macromedia.com/software/player_census/flashplayer/

Martin, K. (1998). Learning in context. *Issues of Teaching and Learning, 4*(8). Retrived February 21, 2005, from http://www.csd.uwa.edu.au/newsletter/issue0898/learning.html

Muukkonen, H., Hakkarainen, K., & Lakkala, M. (1999). Collaborative technology for facilitating progressive inquiry: Future learning environment tools. In C. Hoadley & J. Roschelle (Eds.), *Proceedings of the CSCL '99: The Third International Conference on Computer Support for Collaborative Learning* (pp. 406-415). Mahwah, NJ: Lawrence Erlbaum. Retrived January 19, 2004, from http://web.archive.org/web/20000916210308/http://kn.cilt.org/cscl99/A51/A51.HTM

Najjar, J., Ternier, S., & Duval, E. (2003). *The actual use of metadata in ARIADNE: an empirical analysis.* Retrieved January 20, 2005, from http://rubens.cs.kuleuven.ac.be:8989/ariadne/CONF2003/papers/NAJ2003.pdf

Wilson, S. (2001). *Comment & analysis: Why context Is king.* Retrived February 21, 2005, from http://www.cetis.ac.uk/content/20010827123828

Publication 2

Leinonen, T., Purma, J., Põldoja, H., & Toikkanen, T. (2010). Information Architecture and Design Solutions Scaffolding Authoring of Open Educational Resources. *IEEE Transactions on Learning Technologies, 3*(2), 116–128. http://doi.org/10.1109/TLT.2010.2

Information Architecture and Design Solutions Scaffolding Authoring of Open Educational Resources

Teemu Leinonen, Jukka Purma, Hans Põldoja, and Tarmo Toikkanen

Abstract—This paper presents the open learning object repository and collaborative authoring platform LeMill (http://lemill.net), which has over 7,500 members and over 8,500 reusable learning resources (situation in October 30th, 2009), all created by the community members. The design of LeMill has tackled numerous challenges that hinder the authoring and sharing of educational resources by communities of teachers. This paper describes the research-based design process that was used to solve these challenges. The information architecture of LeMill scaffolds authors toward collaboration and sharing. The licensing scheme encourages reusing and remixing of educational content. In order to make LeMill easy to learn and use we have avoided technical terminology and complicated metadata forms in the user interface. As an open community we have also tackled multicultural and multilingual issues. In this paper, we present the information architecture and design of LeMill, including the technical solutions. We believe that our design solutions will contribute to the goal of creating an open educational resource ecosystem.

Index Terms—Computers and education, social learning techniques, social networking, user-centered design, user generated learning.

1 Introduction

There is something deceptively simple in open educational resources (OER). Almost anything can be used as an educational resource [1] and anything that is offered for free and without major social or economic expectations can be understood to be open. It can look like the internet is full of open educational resources, ready for teachers to adopt and to use. In reality, this doesn't seem to happen. To get people to use open educational resources, there have been projects to define, package, and share them. Currently, research in educational technology has proposed several definitions on what OERs are [2], [3], there are some generally shared standards on how to represent them, and numerous repositories for collecting and sharing them.

As far as we can see, there are still a few missing links before the adoption of OERs can take place in everyday teaching and learning. The most important missing link is that there is no room for OERs in the everyday activities of a median teacher. To fix this, we would need to fix the daily activities of teachers, and we cannot do that directly. However, what we can do is design tools that will support new kinds of everyday practices of teachers and learners.

Because we cannot simply push OERs and the changes they necessitate on teachers and learners, we should try to minimise the required conceptual shifts and changes in learning activities. LeMill (Learning Mill) is a Web community for finding, authoring, and sharing educational resources, designed for easy integration with teachers' existing meaningful tasks and needs. LeMill was developed in 2005-2008 within an EU funded CALIBRATE project (http://calibrate.eun.org), with an initial premise of providing a toolbox for collaborative authoring of learning resources. After CALIBRATE, further development and dissemination has been done in the contexts of the Estonian Tiger Leap Foundation and the EU funded Finnish AVO project (Open Networks for Learning, 2008-2011).

There are implicit and explicit assumptions about what good OERs are: They should be relevant to the learner and thus easily modified to fit the learner's needs. They should be of good quality and contain no factual errors. They should disclose their point of view and in the case of science be free from bias. They should not have hidden costs or prohibiting limitations on use. A good learning resource should also be able to "travel well," to be easily translated and recontextualised [4].

We believe that these requirements can be met by having the resources edited collaboratively and freely online with no restrictions on participation. If OERs can be freely edited, they can be customised for the needs of individual teachers and learners. If they have multiple editors working on them, versions will evolve, making errors and biases easier to find and correct. The license scheme must permit all this: free editing, sharing of edited versions, and combining versions to form new resources. These requirements point toward a uniform and nonrestrictive licensing scheme for all resources.

Since we want LeMill to have good OERs and collaborative authoring seems to be the way to do it, but teachers' existing activities, tasks, and skills do not necessarily include collaborative authoring, we designed

- *T. Leinonen, J. Purma, and T. Toikkanen are with the Media Lab PL 31000, School of Art and Design, Room 378, 00076 Aalto, Finland. E-mail: {teemu.leinonen, jukka.purma, tarmo.toikkanen}@taik.fi.*
- *H. Põldoja is with the Media Lab PL 31000, School of Art and Design, Room 378, 00076 Aalto, Finland, and Tallinn University and LeGroup. E-mail: hans.poldoja@taik.fi.*

Manuscript received 1 Mar. 2009; revised 20 May 2009; accepted 21 Jan. 2010; published online 27 Jan. 2010.
For information on obtaining reprints of this article, please send e-mail to: lt@computer.org, and reference IEEECS Log Number TLTSI-2009-03-0030.
Digital Object Identifier no. 10.1109/TLT.2010.2.

LeMill to provide scaffolding for teachers, so that what they do with their existing skills becomes directed toward collaborative creation.

The main research question of this paper is: How can a Web service design promote use and creation of OERs?

This paper will start by presenting the general challenges related to the design of open educational resource systems, which are not only technological but also social systems. The paper continues by defining relatively concrete design challenges that are part of the overall "wicked problem" landscape. Wicked problem is a concept used by Rittel [5] when referring to the nature of problems common in planning and design practice. After presenting the design challenges we introduce the design methodology used in the process. We call the methodology a research-based design process with focus on software as hypothesis [6]. We continue by presenting design solutions that scaffold authoring of open educational resources. The solutions are mainly decisions related to information architecture: ways of organising, structuring, and enabling collaborative authoring and sharing of educational resources online. We conclude by comparing LeMill's design solutions to other popular repositories and learning resource authoring services.

2 Design Challenges

When starting the LeMill project our initial design challenge was the assumption that European teachers do not share their learning materials nor do they improve them in a collaborative way. Beyond this challenge we can see more general challenges related to European and international educational politics. These are, for instance, differences in the results of educational systems in different countries, which cause problems in recognising educational degrees in other countries. Not recognising educational degrees in a pan-European level hinders the free movement of people, which is one of the basic components of the European Union and acknowledged as a fundamental right for EU citizens.

While our task was not to solve the problems related to the rights of EU citizens, as designers we considered it important that we are aware of the the big picture. Focusing is not possible if one does not know the context. When narrowing down the design challenge to problems related to sharing of learning materials and improving them in a collaborative way, we already implicitly defined the general design solution. This is common in design thinking where the fact that problems are wickedly incomplete and often contradictory is taken for granted [7], [5], [8]. A designer's way of approaching a problem includes the idea that all problems have multiple solutions and every formulation of a problem is simultaneously an attempt to solve it. According to Nelson and Stolterman, ordinary problem solving is reactive to unwanted states, while designing is about creating a positive addition to the present state [7]. The designer cannot assume that the truth about optimal design is there to be found. Instead, the designer can point a way and say that choosing this way has some benefits.

We chose to work with teachers because they are the part of each country's educational system that has direct effects on learning outcomes. Within the educational system, changes in teaching are easier to track than changes in learning. If we had worked outside of the educational system (self-learning, open learning, and networked learning) we would have positioned ourselves as outsiders to our pan-European problem, that of recognising educational outcomes from different educational systems.

During design and development the main design challenge broke down into smaller, often more urgent subchallenges. These subchallenges represent recurring themes in LeMill's design and we think they can be expressed as general design problems in OER repositories and services. These subchallenges are:

1. Lack of collaboration and peer production of learning materials.
2. Lack of reuse and remixing.
3. Limited access and poor usability.
4. Barriers related to multilingualism.
5. Poor use of the underlying principles of the Web, such as openness and "linkedness."

In Section 4, we will argue for and explain our solutions to these subchallenges.

3 Methodology and Design Process

Our design methodology is called "research-based design with software as hypothesis" [6]. In several earlier design and research projects aiming to develop new learning technology (FLE, Fle2, Fle3, MobilED, Hauki, and Kuha) we have noticed that people create meaningful ways of using the tools that surround them, and, from the perspective of tool design, often do not know beforehand what tools they really need. The consequences and the affordances of the tools are realized only when they are used in the real world. With LeMill, our aim was to design learning technology in an open dialogue between designers and the target group (in this case teachers) and provide them with software prototypes. With these prototypes we can design affordances (as understood by Norman [9]) that will likely make sense for the teachers at first glimpse.

The relationship between meaning created in action and tools can be illustrated with an example from school architecture. An auditorium and a teacher's podium are tools that form learning spaces. The architecture, fixtures, furniture, and props in the space quite openly communicate and support certain types of teaching and learning. In complex social activity systems, all new tools bring changes to existing activity systems. A new tool should communicate the changes needed in the system. In our context of educational technology this means that the designed tools and artifacts are always also communicating what teaching and learning with them could be like. In this sense, software tools can be presented as hypotheses about teachers' activities. They can succeed or fail at inducing activities that teachers are willing to integrate into their everyday teaching.

Research-based design with software as hypothesis is not to be confused with design-based research. In design-based research [10], [11], the aim is to do research with designed interventions into real-world situations [6]. In *design-based research* design interventions are a research method. In *research-based design*, the design is the main outcome and anthropological (or quasi-anthropological) research helps to

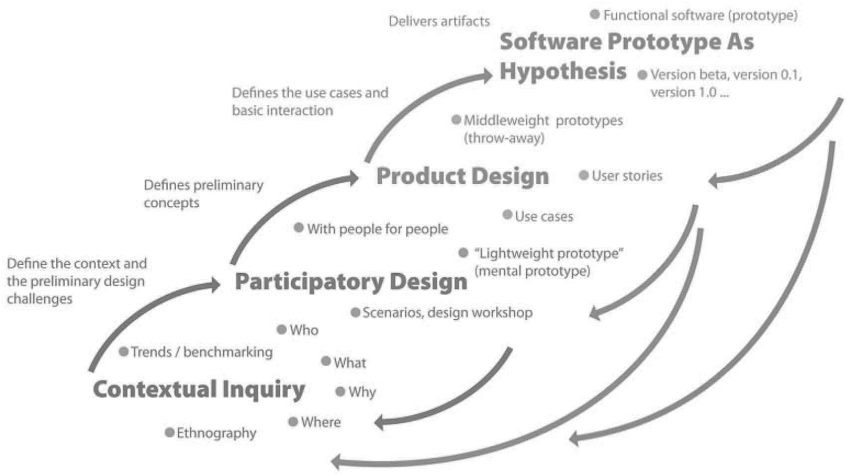


Fig. 1. Research-based design process [6].

draw routes to that outcome.[1] Our process of research-based design aiming to design a new tool is divided into four iterative phases which happen partly in parallel:

1. contextual inquiry,
2. participatory design,
3. product design, and
4. production of software as hypothesis (see Fig. 1).

The process resembles a hermeneutic circle where all research and design operations increase the researchers' and the designers' understanding of each other and the context [6].

As part of the research-based design process, LeMill was developed by using the principles of scenario based design [12] and agile software development methods [13]. The design process was carried out and documented in a publicly available software development environment, called Trac (http://lemill.org).

The *contextual inquiry* phase included observation of teachers' computer use with a special focus on searching of online learning materials. In addition we benchmarked several other online services. These were MediaWiki (http://www.mediawiki.org), MIT's Open Courseware (http://ocw.mit.edu), Connexions, (http://cnx.org), MERLOT (http://www.merlot.org), Pachyderm (http://www.nmc.org/pachyderm), and eduCommons (http://cosl.usu.edu/projects/educommons). Teachers were also asked to use these systems and relate their experiences.

In the contextual inquiry phase our impression was that median teachers in the year 2005 hardly used online learning materials. According to a study conducted in 2006 in European countries [14], 40-85 percent (depending on country) of teachers have used computers in class in the last 12 months, 70-90 percent consider themselves competent in using ICT, and 70-95 percent have used material retrieved from the internet. However, in our observations, most of the teachers used very limited computing skills to produce learning resources: a basic knowledge of office software and using copy-paste to add internet resources was enough for most of the teachers.

Participatory design sessions with one researcher-designer and 2-3 teachers were organized in Estonia, Finland, Hungary, and Norway. The teachers read prepared scenarios and then discussed each scenario in a structured group interview led by the researcher-designer. The participants were then asked to visualize the proposed system as they imagined it and explain their drawing. The researchers recorded the sessions and wrote summaries of them into the Trac system.

During *product design* we realized that we were designing and developing a new tool: something to which none of the existing learning resource authoring tools could contribute. When analyzing the participatory design sessions, we noticed that teachers often do not know what kind of tools they really need and their wishes are influenced by tools that they currently use. We had to balance this reliance on existing tools and their frameworks with the affordances of the new tool. This balancing was an iterative process with teachers, as we gradually became better at understanding the perceived usefulness of each feature.

Our *software as hypothesis* is the LeMill service. We believe that with it—a simple Web-based tool that provides a clear structure for learning resources—teachers can create communities of practice that share and create open educational resources.

4 Design Solutions

This section presents our solutions to the design challenges outlined in Section 2.

4.1 Scaffolding Collaboration and Peer Production

The lack of collaboration and peer production of learning materials was the first of the design challenges. The issue

1. Other sources of confusion are that sometimes a design that is based on results of any usability research is called research-based design and in an educational context any design that implements a researched instructional theory or pedagogy can be called research-based design.

was considered from several points of view, including the basic structure of the service, the level of "wikiness" that would rather benefit than become an obstacle for collaboration, basic concepts and their relations, and the workflows of collaboration, and peer production.

The overall tasks that teachers should be doing in LeMill were deduced from participatory design sessions (http://lemill.org/trac/wiki/DesignSessionResults) and later from workshops with teachers. The structure of LeMill and the available features on each page should provide scaffolding for these tasks. The main tasks were defined as 1) finding resources to use (illustrations and exercises), 2) finding new teaching methods, and 3) modifying resources to better suit a particular learning context. In the participatory design sessions we noticed that when planning their teaching, teachers are primarily interested in using some new teaching or learning methods or tools and only secondarily are interested in the curriculum in which these could be utilized. Based on this discovery, we decided that the top level navigation in LeMill should be split into four segments: Content, Methods, Tools, and Community.

Also apparent from the design sessions was that teachers are generally wary of collaboration and resource creation, pointing out problems with copyright, motivation, and high threshold for joining a new community. While from a workflow perspective LeMill resembles a wiki, its user interface is quite far removed from that of Wikipedia for instance. While a traditional wiki-like interface promotes coediting among a community of technologically savvy users, this is not sufficient to encourage teachers to collaborate, as participation in wikis requires mastering a relatively complex syntax and the environment requires joint continuous efforts to maintain a coherent structure. To support collaboration and peer-production among teachers we noticed that on top of the "wikiness" we must have additional scaffolding that presents the information architecture and the concepts in a language that teachers already know and are comfortable with.

For instance, Methods and Tools are familiar concepts for pedagogically minded teachers. Methods are descriptions of various pedagogical methods, activities, games, and other ways of teaching and learning. Methods also represent LeMill's unique take on Learning Objects (LOs) and Learning Design (LD). While most online LO repositories primarily contain learning objects for learners, LeMill focuses on resources that teachers can utilize to improve their teaching. LOs have been criticized for their unfounded promise of Lego-like combinatorics, which would only be possible if they were instructionally empty [15]. Learning Design (LD, [16]) on the other hand adds instruction theory to learning objects, but the level of description required for IMS-LD modeling is too cumbersome for our needs of easy access and online editing, and on the other hand is incapable of representing some advanced pedagogical models [17]. In LeMill methods are treated like other learning resources and it is up to the teachers to decide how a certain method should be used with certain content. LeMill's LOs are not supposed to be fully machine readable or used in automated instructional sequences. It is assumed that there is always a teacher to decide how resources are to be used. If a teacher is there to contextualize the resources, the decontextualized nature of LOs is not a problem [18].

The Content section contains more typical learning resources. Content resources are built on one of six available templates. The templates are basic scaffolding tools that make it easier for people to create Web content [19], [20]. Our templates are: webpage, presentation, exercise, lesson plan, school project, and PILOT (Progressive Inquiry Learning Object Template [21]). The main concepts and divisions of LeMill are described in Fig. 2.

An important aspect of LeMill is the authoring workflow. We would have preferred to keep the authoring workflow as simple as possible, but participatory design sessions revealed that teachers had many reservations about releasing unfinished or partial resources. So there had to be a division to drafts and published content. However, that division does not need to apply to resource types that don't have a precedent for such division. Our judgement has been that methods, tools, references, PDFs, learning stories, and media pieces do not need to have a draft version. Only template-based content types should have drafts (see Fig. 2).

Drafts were initially created as public to encourage collaboration but without prominent author information to lower the threshold of creating unfinished content. Because of feedback of teachers we had to make drafts private by default and made a third option of "public draft." Publishing a resource is encouraged by allowing only published resources to have cover images. When resources are published, they are visible for all and editable by all.

We initially designed the communities in LeMill to form around collaborative learning resource creation. Each resource can be adopted by a group. Anybody can join a group, but joining a group is the precondition for editing a resource. Later, when we noticed that groups were also used to form courses or workshops, and that these groups collected interesting learning resources, we allowed resources to be adopted by several groups. Discussion about learning resources was initially limited to happen within groups, but as these discussions were rare, the threshold to start one stayed high. We tried linking these discussions to resources with similar "discussion" links as seen in Wikipedia, but the concept became complicated when resources could belong to several groups. Finally we migrated all discussions about resources to happen within the resources themselves and having groups only aggregate these discussions.

We have also tried two solutions for branching different versions of a resource, but we are not satisfied with either. At first we allowed versioning, but found that teachers were too eager to use it in avoiding modifying each other's works, with a detrimental effect to collaboration. The second attempt was when there was an existing biology textbook that an author wanted to publish in LeMill, but didn't want it to be changed by anyone. We allowed the locking down of resources so that only author can edit them, but with the condition that there can be new branches. This feature also seems to be misused, and we are planning in removing it.

Authoring of learning resources and collaboration around them is encouraged by a teacher's portfolio. For every teacher

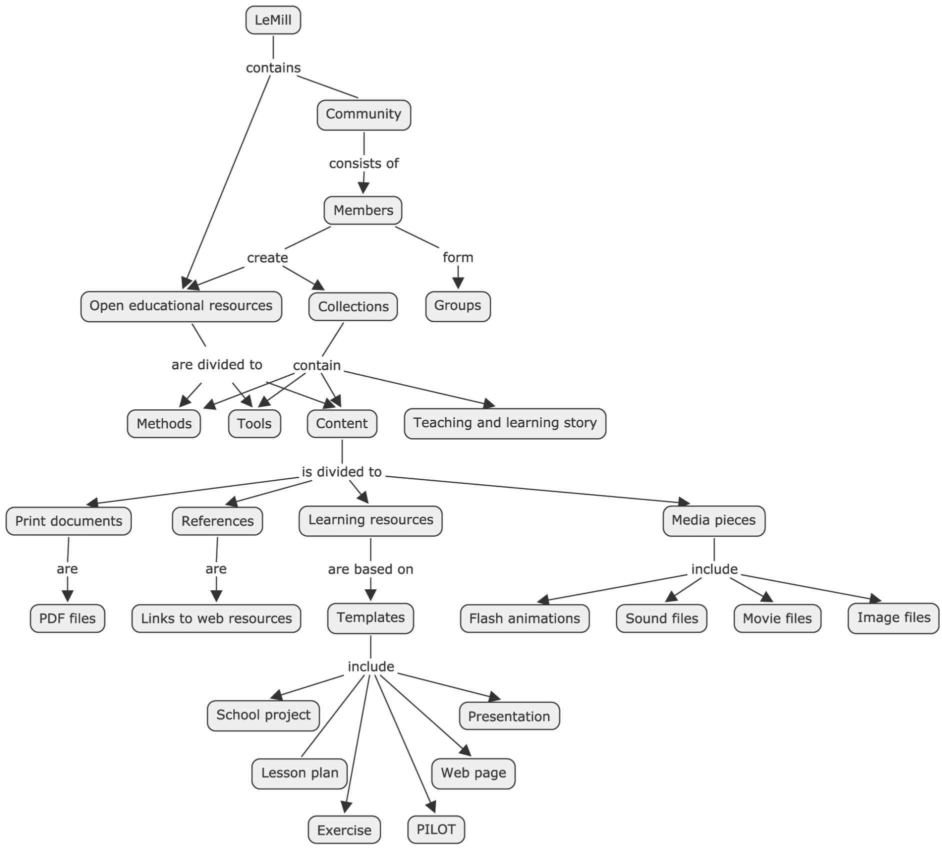


Fig. 2. The central LeMill concepts and their relations.

it keeps track of where the teacher has participated in creation or editing of resources and aggregates these resources. The portfolio also has room for profile and personal information and interests, and these can be used to find other teachers with similar interests.

Individual teachers are also encouraged to collect interesting or high quality resources into their personal collections, which are visible to others. These collections can be formed around any theme, such as "interesting math resources," "good pedagogical advice," etc. A collection can also be used to create a lesson or course plan: by adding content, methods, and tools into a collection, a teacher can create a package that has much of the information that is needed to teach a lesson or a course (Fig. 3).

Teachers can also add "teaching and learning stories" to their collections. These are simple free form descriptions of a collection explaining how the teacher plans to use them or has used them in teaching. Resources that are used in teaching and learning stories automatically and prominently link back to them so as to provide examples and ideas on how to use them. This design addresses the common problem of learning objects not having contextual information about how they should be used [22], [18].

4.2 Scaffolding Reuse and Remixing

Reusability of learning resources has both technical and legal aspects one must consider when designing a service and a tool for this purpose. In the participatory design sessions we found out that teachers are aware of the copyright issues but many of them have a rather practical stand on them. The principle seems to be that if some online content is found useful in teaching and learning it can be used for this purpose freely, including copying, printing, remixing, distributing, etc. However, teachers perceived it as a plus if they could do so legally.

Traditional copyright laws give the creator of an original work the exclusive right to decide how their work is distributed and if it can be adapted. This is a major obstacle for the reuse of learning resources. Learning resources that teachers find from the Web may often need to be adapted to a certain learning context and target group. Doing this for personal learning purposes poses no problem, but distributing the adapted version is a

Fig. 3. An example collection from LeMill.

conundrum. According to copyright laws teachers need an agreement from the holder of the copyright before they can adapt and distribute the learning resource. These legal obstacles can be solved when learning resources are published under an open content license.

From the beginning of the project it was clear that all the content created in LeMill must be published under an open license. However, it was important to choose a licensing scheme that will both protect teachers and give them the possibility to reuse content created by other people. In 2005, when we were pondering this, several licenses were used for educational content. Some systems used GNU Free Documentation License (Wikipedia and other initiatives of the Wikimedia Foundation), some used Creative Commons licenses with noncommercial restriction (MIT OpenCourseWare) and some allowed users to choose between different Creative Commons licenses or all rights reserved (Flickr).

The first important decision was to use the same license for all resources that are created in LeMill. This enables teachers to remix all the resources that they find in LeMill without having to think about license compatibility issues. Second, we decided to choose one of the Creative Commons licenses because their licensing scheme is developed to be understandable by a wide audience. Finally, we were considering between Attribution-Noncommercial-Share Alike (BY-NC-SA) and Attribution-Share Alike (BY-SA) licenses. The noncommercial restriction limits the possibilities of reuse. In the educational context it is problematic for many meaningful ways of reusing content [23]. Therefore, we decided to choose the Creative Commons Attribution-Share Alike license for all content created in LeMill. Back in 2005, it was not the most popular choice for educational content, but recent developments in the field show that it was the right decision. The Wikimedia Foundation has migrated from GNU FDL license to Creative Commons BY-SA license [24]. This made it possible to remix Wikipedia (and other Wikimedia projects') content with LeMill content.

In addition to the new possibilities with Wikipedia and Wikimedia Commons, Connexions has all their content under a compatible CC Attribution (BY) license. The popular photo sharing site Flickr has millions of images under CC BY and BY-SA licenses. A growing number of content with licenses compatible with CC BY-SA makes

LeMill part of a larger OER ecosystem, while content that is under complete copyright can be used by linking or embedding under the Fair Use conventions. For example it is possible to embed videos from YouTube to learning resources in LeMill.

While there are no legal restrictions for remixing the content that is created in LeMill there are still some technical limitations in order to keep the system simple. With remixing we understand the combination of two or more learning resources. So far we have not developed special tools for combining parts of learning resources, but one content type—the media piece—is intended to be used with and within other resources. Web pages, exercises, presentations and PILOTs can all include media pieces. When adding a media piece to a resource, the author can search from existing media pieces or upload a new piece.

The remixing culture makes it easier for us to concentrate on our main focus by outsourcing some of the difficult parts of content creation to services specialized for them. For example, we have had trouble designing and implementing a fast and easy way to create presentations or slide shows as learning resources. Building them from media pieces is cumbersome and leads to dozens of uploaded slides with minimal reuse value. Teachers also want to upload existing Microsoft PowerPoint slidesets as learning resources, which leads to additional problems because then online editing and improving is not possible. Our current solution is to run OpenOffice.org as daemon to export PowerPoint slides into images once they are uploaded, and thus, create editable and "granular" presentations from uploaded material. In addition to putting presentation into LeMill users may use any of the external presentation hosting and creation services like SlideShare (http://www.slideshare.net) or 280 Slides (http://280slides.com) and embed slideshows from there into resources.

Embedding media from another site is actually another popular way to remix content in LeMill. The common method for embedding is to copy and paste an "embed code," a piece of HTML, into a page or blog post. In workshops we have noticed that many teachers are accustomed to office software paradigm for creating content. In office software copying and pasting is the most common solution for moving pieces of text or images from one document to another. Thus we assume that copying an embed code from a site is the cleanest and most versatile way to embed content. The simplicity of copy and paste outweighs the additional user interface clutter that graphical remixing tools would add.

4.3 Scaffolding Access with Minimal Metadata

We suspect that the problem of limited access and poor usability of educational repositories in general is related to different perceptions of what is important for repository curators and repository users [25]. In the participatory design sessions we noticed that average teachers do not know what "metadata" is or see how it could be important to them. Nevertheless, teachers use different kinds of metadata in their daily work. From a technical perspective metadata is important to have, but for teachers it should be invisible, implicit or obviously useful [26].

LeMill is a repository of educational resources. Repositories store objects and metadata, and metadata is there to help find relevant data objects and communicate to other systems about their existence. There are several metadata schemes for educational resources. The Learning Resource Exchange (LRE) Metadata Application Profile v3.0 [27] of the IEEE Learning Object Metadata (LOM) standard [28] defines the metadata that European learning resource repositories should support. These standards can provide a solid base for designing an educational resource repository.

LeMill is built on Zope (http://www.zope.org), a transactional object database. Using an object database allowed us to be very flexible with the actual data model and start with a very minimalistic object scheme. Object schemata are easily updated to have new or changed fields. Having an architecture based on custom object types suggests using adapters to accommodate them to different metadata schemata instead of trying to keep the data structures themselves uniform and compatible. Educational resources from LeMill can be harvested with the Open Archive Initiative Protocol for Metadata Harvesting v2.0 (OAI-PMH) [29] as LRE LOM objects or using DublinCore metadata. In short, the actual data model is there to reflect the priorities of teachers creating content as far as we know them, while satisfying metadata harvesters and queries from other systems comes secondary and is done with adapters. Technically this has proved to be feasible and can be seen as a local mapping solution to problems of metadata interoperability [30].

In LeMill's user interface we altogether avoid the word "metadata," because teachers' existing workflows for preparing material for classes do not use the term. Teachers have a very contextualized short-term need, whereas curators think about the general form and future accessibility of data [25]. If metadata is not perceived as essential for finding resources [25], [31], [32], then we suspect that adding such metadata to content will be perceived as an extraneous and unnecessary task.

To make some metadata relevant, we encourage teachers to browse LeMill. For example, the Content section's front page has emphasized links to browse by language, subject area, target groups, and tags, with links to the three most popular tokens for each. Internally, all these browsing options are metadata categories. All of them except tags come naturally from teachers' needs. Free form tagging is a concept familiar from social software and it has been found that teachers adopt it well [33]. After limiting results with one criterion, the browsing view allows the addition of other criteria from drop-down menus so that teachers can end up browsing for example resources in *English* that are about *History* and suitable for *10th grade students* and have the tag *media*.

We assume that the usefulness of metadata in browsing encourages teachers to enter similar metadata to their resources. The data that LeMill collects that can be understood as metadata is presented in Table 1. Only the first four are explicitly asked from teachers and they are all optional. The rest of the fields are created automatically. The teachers may enter metadata when creating the resource, or they may complement them later. Complementation—the "wiki-way"—can be done by any user. LeMill is integrating flexible community-based metadata creation to automated metadata gathering, as described by Duval [26].

TABLE 1
Metadata Fields

Field name	Teacher's input
Tags	free text
Subject area	multiple selection
Target group	multiple selection
Language	suggestion based on the teacher profile's languages, single selection
Publication status	for most resources 'published' or 'deleted', for Content types also 'draft' or 'private'; altered by actions 'publish', 'delete', 'undelete' or 'retract' shown when applicable
Cover image	asked when publishing a resource, can be changed later; for media pieces that are images, automatically use thumbnail image
Creators	automatically added as creator, order of authors depend on size of contribution
Rights	CC BY-SA automatically for most; with references and media pieces several options that refer to original license
CreationDate	automatically added
ModificationDate	automatically updated
Id	automatically generated from resource's title

When presenting metadata fields to teachers we have to use the same terminology as teachers do. For example, in workshops we found out that teachers prefer to use grades instead of a typical age range. Because of this we combined three elements from LRE LOM ("Educational.Intended End User Role," "Educational.Learning Context," and "Educational.Typical Age Range") into a new element named "Target group." Vocabulary values for this element include all the primary education grade levels, preschool education, higher education, adult education, special education, and teachers. In the OAI-PMH script we map these values back to LRE LOM. Instead of "General.Keyword" we use "Tags" in the user interface. We also avoided using technical terminology such as "learning objects" and "learning assets" in the user interface. Instead of these we decided to use "learning resources" and "media pieces."

During the development of LeMill, the data model has gone through several minor changes and adjustments. For instance, we have removed fields that have not been used or have often been misunderstood. One example of an unused field was the link to a video, to demonstrate a method. An example of a confusing field was "learning resource type," a field that was based on LRE LOM element "Educational.Learning Resource Type" and used for references to determine which kind of resource is referenced. We noticed that teachers were uncertain as to what kind of element to choose when the resource was, for example a Web site with simulations and quizzes. We observed that the description texts were providing the same information in an easier way and decided to remove the field altogether.

One example of the difference between metadata for teachers and standardized metadata is the learning resource's cover image. When browsing resources, a cover image can tell a lot about the resource and the effort that has been put into creating it. Metadata standards do not recognize such information. We try to encourage teachers to add cover images to resources by making it a mandatory step in the publication process. Cover images can reuse thumbnail-sized versions of existing media pieces or be newly uploaded images.

In a repository with thousands of objects it is crucial to have metadata that supports finding quality content. One way of ranking resources would be to have a simple rating system. However, our design sessions have indicated that because of variance in teachers' needs, simple five star rating systems are not objective enough. In addition the editable nature of LeMill resources makes ratings counterproductive, as bad ratings follow resources even when their causes are fixed. Instead of a rating system teachers can use a discussion page to give meaningful feedback about the resource. This approach is being used in LeMill, but conclusive results have not yet been gathered. One aspect of this approach is that it blurs the line between commenting and editing content. If you have a constructive comment on a resource, will you write it into the discussion page as a comment, or directly edit the resource itself to reflect the changes, or both?

We have developed ranking algorithms for calculating scores for content, methods, and tools. The score will depend on the way people work on the resource and on the actions that other people have with it. Each object will get initial points when it is published. The score will rise when it is edited further, illustrations are added and external resources are embedded. Since our aim is to support collaborative authoring we will give more points when the resource is edited by more than one member. Points will be added to the score each time other people bookmark the resource into their collections. As a result, resources that are edited by several people and belong to several collections have a higher score. The scores are used to sort search results, generate tag clouds, and display featured resources on the section front pages. These algorithms are modified periodically as we try to balance results to both encourage collaboration and to reward individual efforts.

In a similar way we calculate scores for community members. The member score consists of three parts. First, we sum up the scores for all content, methods, and tools that the member has created. Then the social activities such as sharing teaching and learning stories, participating in the groups, and being added as a contact are scored. Finally the member will receive additional points for fully filling the member profile.

4.4 Scaffolding Multilingual Use

The participatory design sessions were carried out in four European countries—Estonia, Finland, Hungary, and Norway—in four different languages. From the very beginning it was clear that we were designing a multilingual and multicultural tool and service. The results should include ways to translate and localize itself to whatever language. The content should also be easily translatable. Different languages in the site should not confuse the people using the site.

For a multilingual site, there are basically two options: either keep the languages separate, or mix them up in one pool. As LeMill developed from an empty repository, we started with everything in the same pool, and gradually added functionality to allow for different languages to separate to their own resource pools. The upside of keeping everything together is that the repository doesn't appear empty to a representative of a minor language, while the downside is that search results may be flooded with resources in a language that the teacher doesn't understand.

From the beginning each teacher was able to define in their profile the languages that they are fluent in, in the order they think is most suitable, usually placing their native language first, followed by other languages that they can use. This became a very important tool as we noticed that LeMill was starting to be dominated by a few small languages.

Nearly all resources in LeMill have a specified language, and those that don't are causing problems, so in the future they will need to be tagged with a language as well. We use teachers' profile language information to customize both the user interface and the listed resources in search results, featured resources, and browsing views. The list of matching resources is sorted by languages, and then by the individual resource's popularity score. Thus, in search and browsing results, teachers will first see matching entries in their native language, in popularity order, followed by resources in their secondary languages, in popularity order, language by language, and finally in english, if english was not already included.

Resources in languages that the teacher has not listed in their profile will not be shown at all unless explicitly searched for. Teachers can of course access them if they find them. This feature acts to form language clusters within the repository, as the language skills of the teachers define the borders surrounding clusters. Multilingual teachers will of course be positioned as mediators between language clusters.

LeMill encourages translation of resources. Each resource has a link to translate it, and the resource has links to already existing translations. Translations are not assumed to be identical, and certainly cannot be, as the original and the translation can both be further developed by other teachers. The intention is to facilitate the spread of good resources and teaching ideas.

We've identified some specific problems regarding resource languages. Images don't usually have any language content, but their descriptions and titles are written in some language. Would it make sense to tag an image with the language of its description? While it is informative, teachers could easily reuse images regardless of their description language.

Another problem concerns collections, which can contain resources in multiple languages, in addition to the collection's title and its own description. What should the language of a collection be, if its title and description are in Estonian, but all or most resources are in English?

A third problem concerns resources related to language studies. If a resource contains text in English, and instructions in Estonian, which language should it be tagged with? English teachers in Estonia will most likely try to find material for their courses by looking into the pool of English resources, but having a resource that is partly in Estonian will be quite problematic for English teachers in other countries. Short of having separate metadata fields for "teaching language" and "content language," this issue is still unresolved, partly because there is a similar problem with referencing to resources outside LeMill. The referenced resource can be in a different language than the actual reference description and explanation, but there is an ambiguity about what the language field is referring to. LRE LOM's approach of asking for language in "General.Language," "Meta-metadata.Language," and "Educational.Language" allows all of these specifications. However, in most of the cases selecting the language of a resource is obvious, and having these three fields would feel like an unnecessary complication.

A fourth problem is the issue of tags and their languages. Currently tags carry no language information, which means that tag clouds are quite multilingual. It would be technically possible for us to convert all our tags to tuples of tag and language code, but keeping the process of adding tags simple would then be a formidable design challenge. Tag language could be inferred from the language of the resource, except that many content resources are about foreign language learning and thus contain two languages and are labeled in differing ways (see previous paragraph). Inferring tag language from the user's profile would require each tag to have a language specified separately, as tags can be edited by anyone and adding a few tags in your own language shouldn't change the language of other tags. Even a dictionary-based solution has its limitations, as some words can occur in multiple languages and mean either the same thing, or different things.

A multilingual site attracts users from multiple countries and cultures. At the time of writing this paper, LeMill has teachers from 56 countries. Each group of sufficient size seems to form its own codes of conduct and practices of using LeMill. Teachers in some countries have started to write individual course plans as method descriptions, while others have written them into the content section. In some countries teachers need to be able to present their lesson plans and show how they connect to accepted learning goals, where as in other countries there is no need for such detailed plans. As a response new content types were added to the content section: lesson plans and school project plans. One example of cultural differences is the popularity of history as a subject area in Georgian resources, where in other languages it is one of the least used categories. A more detailed comparison of community practices is difficult because of language barriers, which also forces us to trust in community self-organization and self-policing.

4.5 Scaffolding Creation of Small Pieces Loosely Joined

Our fifth design challenge was the poor use of the underlying principles of the Web, such as openness and "linkedness." What we mean with openness is that anyone can join the system, create new resources, have them link to any resource anywhere, and to link to these resources from anywhere on the Web. Because of its elective, haphazard, and unlimited fashion of linking, the Web is said to be formed from small pieces loosely joined [34]. A powerful side effect of ideological linkedness is that because search engines index resources by following links, resources in highly linked and openly traversable repositories are very visible in general search results.

TABLE 2
Provided Protocols and Views

Reader	Provided protocols and views
teacher	web page, 'student view', zipped offline web pages, SCORM-package, PDF
RSS-reader	RSS 2.0
metarepository	OAI-PMH, supported formats LRE LOM and DublinCore

As noted before, our approach to standards is not to build from standards, but to build from teachers' needs and have the result adapt to standards when necessary. All textual resources in LeMill are presented as XHTML. Multimedia uses the normal Web-acceptable image formats, and some rich media are displayed using Flash, which can be considered a de facto standard. As previously discussed, we considered IMS Learning Design (IMS LD) [16] to provide an interesting and advanced description language for pedagogy, but we found it too complicated for easy access and also that it had important restrictions in covering dynamic group behaviors and other advanced iterative methods [17].

If the resources in a repository cannot be exported and transferred to other infrastructures, it cannot claim to be truly open. The most popular LO transfer format is SCORM, and collections from LeMill can be exported as SCORM sequences, stand-alone Web file packages, or pdf booklets. These allow teachers to export their collections and set them up on a Web server, import them to any SCORM compatible LMS, or to print them as handouts.

Referratories or metarepositories that only store the metadata of resources have lately been quite popular, and any open repository should acknowledge them and provide access to them. OAI-PMH [29] support was built into LeMill, as it seemed to be the leading protocol in querying repository contents, had sufficient support for LO metadata, and was already supported by other platforms. LeMill also provides RSS feeds for search results and other dynamic pages. A summary of currently supported protocols and views is presented in Table 2.

To prevent LeMill from becoming a closed silo it is important to make it clear that LeMill is open and readable by anyone, by not hiding information inside members-only areas and by publishing the content with open licenses that make it clear to authors that their creations will be openly available. When LeMill resources are readable in general then technical support for existing open standards and for upcoming new standards is relatively simple to add.

5 Comparison of Design Solutions to Other Learning Resource Repositories

Teachers' expectations for online services in general have been about time and effort savings in finding resources and preparing resources for classes [35], [31], [25], [32]. Peer production is not in the teachers' goals, but should come as a byproduct of resource finding and preparation. OER repositories and LeMill share the same purpose of supporting teachers in finding resources. Yet because LeMill's main design goal is to foster peer production, LeMill omits a few common OER repository features in order to make participation and co-creation easier. LeMill differs from major repositories like Connexions (http://cnx.org), MERLOT (http://www.merlot.org), OER Commons (http://www.oercommons.org), and its sister project Learning Resource Exchange for Schools (http://lreforschools.eun.org) by keeping the user interface much more simple. The resources cannot be rated and they have less visible metadata.

Simplicity in browsing makes simplicity in editing easier to achieve. In Connexions, creating Modules is done in their own CNXML language; in MERLOT, OERCommons, and LREforSchools, resources are submitted by providing a link and entering metadata, after which the resource goes through a review process. Even as resources are often published with open licenses, only the author or editor can modify the resource. Only wiki-based OER projects like Wikiversity (http://wikiversity.org), Wikieducator (http://wikieducator.org), and LeMill expect collaborative editing to be the default.

Mixing languages is also typical for LeMill, but as a sitewide feature it may be a passing phase, as content in foreign languages are only displayed when enough resources in familiar languages are not found. MERLOT and Connexions use English as the only user interface language. Connexions has ≈ 90 percent of resources in English and MERLOT's ratio is unknown, although probably in the same region. Wikiversity and Wikieducator use separate subsites for every language, with courses linking to other languages if the translations are available. There is also a multilingual beta.wikiversity.org for languages that have not reached critical mass of active users. LREforSchools uses the same principles as LeMill for dealing with languages: the user interface is translated into several languages and the content is syndicated from several languages. LREforSchools has a special tag for "Travel well"-resources that do not rely on language.

Encouraging creation of small resources is a goal that is related to reuse and remixing. For finding images and pieces to use in teaching, teachers can rely on Flickr and similar services, but for the purpose of composing a new resource to be shared with other teachers, the parts should have a license that permits that. Hosting suitable media pieces inside the repository facilitates remixing and allows automated attribution. While Wikiversity uses resources from Wikimedia Commons quite naturally, other repositories expect authors to have prepared material that is clear from copyright issues.

5.1 Authoring Tools

In addition to OER repositories, there are authoring tools for learning resources that have repository-like features. Their focus is on creating resources in a certain presentation format, which then can be downloaded or played on site.

LAMS is a tool for authoring IMS LD compliant learning sequences and has a community where sequences are published and shared (http://www.lamscommunity.org). Playing LAMS sequences requires a dedicated server. Building a sequence is done with a drag-and-drop editor, but as the task is to model a learning scenario, the entry barrier is quite high. Furthermore, viewing a learning sequence requires the creation of a demo account. The RELOAD editor allows offline editing of IMS LD and SCORM sequences, but it is aimed for more technical users. While IMS LD has promise, modeling learning sequences is beyond LeMill's goals of supporting teachers in their first steps at collaborative authoring.

5.2 Other Approaches

ALOCOM is an innovative approach for reusing learning objects. ALOCOM is a model about content of learning objects, but instead of providing an online service for composing LOs from LOs, it is used by plugins within popular office software [36]. These plugins try to search the ALOCOM repository for smaller "Content Fragments" that could be useful for the LO that the teacher is trying to create. The LO can then be sent to the repository where it will get automatically parsed into Content Fragments usable by other teachers. By using office software that the teachers already know well, it bypasses many usability issues and in a way provides scaffolding. This approach is highly dependent on automated parsing of LOs and would be less effective for the very heterogenous needs of European teachers. However, doing ALOCOM ontology parsing in LeMill, uploading LeMill content to the ALOCOM repository and fetching Content Fragments from ALOCOM could be a future option.

Also of note is eduCommons (http://educommons.com), a content management system for OpenCourseWare projects. The idea is that a school can have an eduCommons server and host its courses there. These hosted courses are syndicated to other OpenCourseWare servers and repositories. This is a great approach for institutions that can commit to the OpenCourseWare Consortium, as each eduCommons site can set up its workflows and practices as they see fit. But as the consortium targets only higher education, modifying an eduCommons site to serve primary or secondary school teachers would be a design project of its own. In one phase of the project, LeMill was perceived to provide a similar service for basic education: LeMill installations were supposed to form a network with syndicated searches. However, as a lively initial community was a necessity, we concentrated our efforts to one LeMill site.

6 Conclusions

The design of LeMill aims to combine many aspects that are important in authoring and sharing of open educational resources. We have tried to solve several fundamental challenges that hinder European teachers from creating and sharing open educational resources. The information architecture presented in LeMill can be part of the solution helping European teachers share more their learning materials and improve them in a collaborative way.

Thorough validation and evaluation work has shown that LeMill is at least a partial success. From the very beginning of the project we aimed to create a living community—or actually make it a platform for communities. Today LeMill has more than 7,500 members from 56 countries. Teachers from some countries, such as Georgia or Estonia, have their own strong communities, while teachers from some countries like Hungary or Finland have not yet formed a self-sustaining community. Together with Connexions, Wikiversity, and WikiEducator LeMill is currently one of the largest OER initiatives based on peer-produced content.

LeMill has currently over 8,500 learning resources. In November 2007 Ochoa and Duval [37] calculated that average growth for Connexions to be 1.8, for MIT OCW 1.0, and for MERLOT 4.6 new resources per day. In the same time period LeMill's growth was 3.4 resources per day and in the fall of 2009 the growth rate was 8.0 (not including media pieces).

LeMill has been evaluated by pedagogical researchers working in close cooperation with teachers [38]. The evaluation included authentic trials in schools, national focus group discussions in six European countries, pre-pilots, workshops, and evaluation exercises with teachers between 2005 and 2008. The results were compared to the general ICT capabilities of the teachers with the SIPTEC framework. During the evaluation, one hypothesis concerned LeMill successfully supporting computer supported collaborative learning in knowledge building communities and trialogical learning. This hypothesis was supported by the findings of the study, mentioning the emergence of national communities, peer learning among teachers, extra-cognitive mechanisms, social presence, and the importance of coevolutionary methods in the development of LeMill. Another hypothesis concerning long term impact of LeMill showed promise, but could not be verified in the study as more time was needed to truly see the long term effects [38].

However, the main question for this paper is what part the design of LeMill has played in achieving these results. The design solutions have been

1. making social activities like building collections, building portfolios, discussing and forming groups centered on resources, and having reuse and remixing an explicit part of resource creation,
2. publishing all resources under a license that permits remixing,
3. making metadata creation implicit and manual entry of metadata minimal,
4. mixing languages together and personalizing views based on language preferences, and
5. encouraging the creation of small resources and keeping them open to the larger Web.

In discussions with teachers from several countries one of the main reasons why LeMill has been taken into use by the teachers is its ease of use. It is said to be simple and elegant, while at the same time showing respect for freedom of expression, freedom of assembly, and the existence of different languages and cultures.

However, by looking at the actual amount of collaborative editing in LeMill, the numbers are low. Only 5.5 percent (270 of 4,890) of resources (excluding media pieces and resources that are clearly stubs, have no tags or language information) have been edited by more than one author. For those resources that are assigned to groups, 9.7 percent (128 of 1,326) have been edited by more than one author. It is a positive finding that assigning resources to groups has a noticeable effect. There are some known factors influencing these numbers. One is that collaborative editing is defined quite strictly: only changes in the actual body text of a resource count; adding tags or fixing missing metadata doesn't count. Another is that many of the resources are created in teacher training sessions and while we now try to delete them afterwards, there are still large amounts of low quality content that is generally not visible, but affects these statistics. Our design solutions for supporting collaboration have not created a major change in teachers' behavior in this aspect.

We may also have been mistaken in our assumption that the smaller granularity of resources lowers the threshold of resource creation. Ochoa and Duval [37] found that repositories that feature full courses have a more active user base than repositories that concentrate on resources of smaller granularity. A course is a natural context for teachers to return and work on. Instead we have had to rely on workshops, competitions, and teacher training sessions to provide temporary meaningful contexts for resource creation.

We have found that it is difficult to maintain the separation between design work in LeMill and "community gardening." In social software, a design solution can create affordances, but community conventions and introduced rules can override and replace the designers' intentions. Design can be used to resist certain habits, like the teachers' preference of keeping unfinished resources private. A designer as a community moderator can do the same thing with a simple discussion post. In LeMill dissemination, one of the designers has held the majority of teacher workshops and gained many important insights into the design problems from teachers. This learning has been mutual: teachers in the workshops have learned about LeMill's design intentions and in turn adapted to them. This is typical for a "wicked problem"—even when there seems to be progress toward solving it, it is difficult to point out which of the multiple solution attempts actually worked. In the spirit of openness, we have here presented our attempts.

ACKNOWLEDGMENTS

This research was partly funded by ESF grant 7663 and MER targeted research 0130159s08.

REFERENCES

[1] T. Leinonen, "Urinal as a Learning Object," http://flosse.dicole.org/?item=urinal-as-a-learning-object, 2005.
[2] D. Wiley, "RIP-Ping on Learning Objects," http://opencontent.org/blog/archives/230, 2010.
[3] S. Schaffert and G. Geser, "Open Educational Resources and Practices," *eLearning Papers,* http://www.elearningeuropa.info/files/media/media14907.pdf, vol. 7, 2008.
[4] L. Petrides, C. Jimes, and A. Karaglani, "'Travel Well' Open Educational Resources: A Presentation of Ongoing Research," Presentation in iSummit 2008, Sapporo, http://icommons.pentabarf.org/programme/iSummit08/attachments/7_ISKME_TravelWell.pdf, July 2008.
[5] H. Rittel, "On the Planning Crisis: System Analysis of the 'First and Second Generations,'" *Bedrifts Okonomen,* vol. 8, pp. 390-396, 1972.
[6] T. Leinonen, T. Toikkanen, and K. Silfvast, "Software as Hypothesis: Research-Based Design Methodology," *Proc. Participatory Design Conf.,* 2008.
[7] H.G. Nelson and E. Stolterman, *The Design Way. Intentional Change in an Unpredictable World.* Educational Technology Publications, 2004.
[8] H. Rittel and M. Webber, "Dilemmas in a General Theory of Planning," *Policy Sciences,* vol. 4, pp. 155-169, 1973.
[9] D. Norman, *The Design of Everyday Things.* Basic Books, 1988.
[10] S.A. Barab and K. Squire, "Design-Based Research: Putting a Stake in the Ground," *J. Learning Sciences,* vol. 13, no. 1, pp. 1-14, 2004.
[11] Design Based Research Collective, "Design-Based Research: An Emerging Paradigm for Educational Inquiry," *Educational Researcher,* vol. 32, no. 1, pp. 5-8, 2003.
[12] J.M. Carroll, *Making Use: Scenario-Based Design of Human-Computer Interactions.* The MIT Press, Sept. 2000.
[13] K. Schwaber and M. Beedle, *Agile Software Development with Scrum.* Prentice Hall, 2001.
[14] W. Korte and T. Hüsing, "Benchmarking Access and Use of ICT in European Schools 2006: Results from Head Teacher and a Classroom Teacher Surveys in 27 European Countries," http://www.elearningeuropa.info/files/media/media11563.pdf, 2006.
[15] D. Wiley, "Connecting Learning Objects to Instructional Design Theory: A Definition, a Metaphor, and a Taxonomy," *The Instructional Use of Learning Objects,* D. Wiley, ed. Agency for Instructional Technology and the Assoc. for Educational Communications and Technology, ch. 1., http://reusability.org/read, 2000.
[16] IMS, "IMS Learning Design Best Practice and Implementation Guide," technical report, IMS Global Learning Consortium, http://www.imsglobal.org/learningdesign/ldv1p0/imsld_bestv1p0.html, Jan. 2003.
[17] J. Dolonen, "Empirical Study of Learning Design," http://calibrate.eun.org/shared/data/calibrate/deliverables/D3p1_v2.pdf, 2006.
[18] P.E. Parrish, "The Trouble with Learning Objects," *Educational Technology Research and Development,* vol. 52, no. 1, pp. 49-67, Mar. 2004.
[19] J. Pokorny, "Design: Static Pages are Dead: How a Modular Approach Is Changing Interaction Design," *Interactions,* vol. 8, no. 5, pp. 19-24, 2001.
[20] A. Désilets, S. Paquet, and N.G. Vinson, "Are Wikis Usable?" *Proc. Int'l Symp. Wikis,* http://www.iit-iti.nrc-cnrc.gc.ca/iit-publications-iti/docs/NRC-48272.pdf, pp. 3-15, 2005.
[21] H. Põldoja, T. Leinonen, T. Väljataga, A. Ellonen, and M. Priha, "Progressive Inquiry Learning Object Templates (PILOT)," *Int'l J. E-Learning,* vol. 5, no. 1, pp. 103-111, 2006.
[22] N. Friesen, "Three Objections to Learning Objects and e-Learning Standards," *Online Education Using Learning Objects,* R. McGreal, ed., pp. 59-70, Routledge, 2004.
[23] H. Möller, "The Case for Free Use: Reasons Not to Use a Creative Commons -NC License," http://freedomdefined.org/Licenses/NC, 2007.
[24] http://meta.wikimedia.org/wiki/Licensing_update/Result, May 2009.
[25] A. Margaryan and A. Littlejohn, "Repositories and Communities at Cross-Purposes: Issues in Sharing and Reuse of Digital Learning Resources," *J. Computer Assisted Learning,* vol. 24, no. 4, pp. 333-347, 2008.
[26] E. Duval and W. Hodgins, "Making Metadata Go Away: 'Hiding Everything but the Benefits,'" *Proc. Int'l Conf. Dublin Core and Metadata Applications: Metadata Across Languages and Cultures,* 2004.
[27] LRE, "The EUN Learning Resource Exchange Metadata Application Profile v3.0," technical report, European Schoolnet, http://lre.eun.org/sites/default/files/pdf/AppProfilev3p0.pdf, June 2007.
[28] *IEEE 1484.12.1-2002, Learning Object Metadata Standard, IEEE Standards Department, Final Draft,* IEEE, http://ltsc.ieee.org/wg12/files/LOM_1484_12_1_v1_Final_Draft.pdf, July 2002.
[29] OAI, "The Open Archives Initiative Protocol for Metadata Harvesting v2.0," technical report, Open Archives Initiative, http://www.openarchives.org/OAI/2.0/openarchivesprotocol.htm, June 2002.
[30] M. Nilsson, P. Johnston, A. Naeve, and A. Powell, *The Future of Learning Object Metadata Interoperability,* pp. 255-313. Informing Science Press, 2007.
[31] G. Thomas and M. Horne, "Using ICT to Share Tools of the Teaching Trade," Technical Report BEC1-15129, Becta, http://partners.becta.org.uk/upload-dir/downloads/page_documents/research/open_source_teaching.pdf, 2004.
[32] P. Smith, P. Rudd, and M. Coghlan, "Harnessing Technology: Schools Survey 2008," technical report, Nat'l Foundation for Educational Research, http://partners.becta.org.uk/index.php?section=rh&rid=15952, Sept. 2008.

[33] R. Vuorikari and H. Põldoja, "Comparison of Educational Tagging Systems—Any Chances of Interplay?" *Proc. Second Workshop Social Information Retrieval for Technology Enhanced Learning,* R. Vuorikari, B. Kieslinger, R. Klamma, and E. Duval, eds., CEUR-WS.org, http://sunsite.informatik.rwth-aachen.de/Publications/CEUR-WS/Vol-382/paper1.pdf, 2008.
[34] D. Weinberger, *Small Pieces Loosely Joined: A Unified Theory of the Web,* Basic Books, May 2003.
[35] PricewaterhouseCoopers, "Using ICT in Schools: Addressing Teacher Workload Issues," Technical Report 2003057, Dept. for Children, Schools, and Families, http://www.dcsf.gov.uk/research/programmeofresearch/projectinformation.cfm?projectid=14012, 2004.
[36] K. Verbert and E. Duval, "Evaluating the ALOCOM Approach for Scalable Content Repurposing," *Creating New Learning Experiences on a Global Scale,* E. Duval, R. Klamma, and M. Wolpers, eds., pp. 364-377, Springer Berlin, 2007.
[37] X. Ochoa and E. Duval, "Quantitative Analysis of Learning Object Repositories," *IEEE Trans. Learning Technologies,* vol. 2, no. 3, pp. 226-238, 2009.
[38] A. Kárpáti, "Final Evaluation Report," technical teport, CALIBRATE, IST-028205, European Commission, http://calibrate.eun.org/shared/data/calibrate/deliverables/D4_3_Evaluation_ReportFinal.pdf, 2008.

Teemu Leinonen is a designer and a professor of new media design and learning in the Media Lab Helsinki at the Aalto University School of Art and Design.

Jukka Purma is a researcher and a software developer in the Media Lab Helsinki at the Aalto University School of Art and Design.

Hans Põldoja is a designer and a research associate in the Institute of Informatics at the Tallinn University and a doctoral candidate in the Media Lab Helsinki at the Aalto University School of Art and Design.

Tarmo Toikkanen is a psychologist, researcher, and software developer in the Media Lab Helsinki at the Aalto University School of Art and Design and is working toward the PhD degree at the University of Helsinki.

Publication 3

Põldoja, H., Duval, E., & Leinonen, T. (2016). Design and evaluation of an online tool for open learning with blogs. *Australasian Journal of Educational Technology, 32*(2), 64–81. http://dx.doi.org/10.14742/ajet.2450

Design and evaluation of an online tool for open learning with blogs

Hans Põldoja
Tallinn University, Estonia

Erik Duval
Katholieke Universiteit Leuven, Belgium

Teemu Leinonen
Aalto University, Finland

Blogs are used in higher education to support face-to-face courses, to organise online courses, and to open up courses for a wider group of participants. However the open and distributed nature of blogs creates problems that are not common in other learning contexts. Four key challenges related to the use of blogs in learning were identified from earlier research: fragmented discussions, a lack of coordination structures, weak support for awareness, and a danger of over-scripting. The *EduFeedr* system has been designed to address these issues. In this paper, the authors present their evaluation of its design and effectiveness in a total of 10 courses. The results indicate that learners find the *EduFeedr* system useful in following discussions and in comparing their progress with other learners. The coordination and awareness issues are seen as more important than the fragmentation of discussions and a danger of over-scripting.

Introduction

Blogs are used in higher education to provide a space for reflection, a forum for discussions, a portfolio of completed assignments, and for opening up courses for a wider group of participants. While some recent research has focused on the pedagogical aspects of using blogs in higher education, Sim and Hew (2010) suggest that one focus of future research should be the development of web technologies that will enhance the conversational and interactive aspects of blogging. Our study focuses on designing and evaluating an online tool that aims to address some of the issues that impede the use of blogs in online and blended learning courses.

A blog is a website where the content is comprised of posts that are displayed in reverse chronological order. A typical blog is a personal website that is written by a single person; however it is also possible to have several authors. Readers can become engaged by writing comments on blog posts. Syndication technologies such as really simple syndication (RSS) and *Atom* enable readers to receive new posts and comments automatically. All blogs and their interconnections are often referred to as the *blogosphere*. The blogosphere can be seen both as a social network and as an ecosystem.

The possibilities for using blogs in learning became evident soon after blogs emerged (Oravec, 2003; Williams & Jacobs, 2004). Sim and Hew (2010) identified six major applications for blogs in education: (a) maintaining a learning journal, (b) recording personal life, (c) expressing emotions, (d) communicating with others, (e) assessment, and (f) managing tasks.

Kim (2008) suggests that the use of blogs may help to overcome various limitations of other computer-mediated communication systems, such as difficulties in managing communication, passiveness of students, lack of ownership, instructor-centeredness, and limited archives of communication. Previous studies show that reading other blogs and receiving feedback on one's own blog posts were the more effective aspects of using blogs in learning (Churchill, 2009; Ellison & Wu, 2008). Blogs are useful in disciplines that require students to discuss, write, reflect, and make comments about content or ideas (Cakir, 2013). Blogging has been found particularly beneficial in teacher education because it can motivate learners, foster collaboration and cooperation, promote different instructional practices, and enrich the learning environment (Goktas & Demirel, 2012). Teachers who acquire these competences during the blogging assignments can later apply these methods in their own teaching.

Blogs are a common platform for creating a personal learning environment (PLE). Dabbagh and Kitsantas (2012) distinguish between three levels of blog use for self-regulated learning in PLEs: (a) using blogs for personal information management, (b) using blogs for social interaction and collaboration, and (c) using blogs for information aggregation and management. In the first level, learners use a blog as a private journal to set learning goals and plan for course assignments. In the second level, they make blogs public and allow others to comment on their posts. In the third level, learners integrate their blogs with other web services, for example by adding the blog to an RSS aggregation service. These three levels are related to the six major educational uses of blogs referred to earlier in this introduction (Sim & Hew, 2010): *personal information management* involves keeping a learning journal and recording personal life, *social interaction and collaboration* relates to communication with others, while *information aggregation and management* can be associated with managing tasks and assessment. This research paper partly addresses all three aspects of using blogs as PLEs, but focuses primarily on the third level by studying the aggregation and management tools for online courses.

One of the important characteristics of blogs is openness. Blogs follow the basic principles of the open web such as decentralisation and universality (Berners-Lee, 2010). The decentralised architecture of blogs allows anybody to set up a blog on their own server or use a free blog hosting site. Universality enables any blog post or page to be linked to by using a unique address. The open nature of blogs makes blogging especially suitable for pedagogical approaches that emphasise public discourse, open participation and self-directed learning (McLoughlin & Lee, 2007). In these types of learning contexts, it is common for learners to be connected to more than one educational institution. The authors' initial motivation to study the coordination of blog use in online courses evolved from a number of courses in which blogs were used to open up the course for external participants.

Open online courses with blogs

The term *open learning* refers to learning that takes place online and is more or less open for anyone to participate in. In this way, open learning is an umbrella term that covers various kinds of online courses, such as massive open online courses (MOOCs) and blog-based open online courses. This paper however, does not address classical *open distance learning,* but focuses specifically on using the open web for learning.

A MOOC is an online course with open access and a large number of participants. Some MOOCs use special platforms such as *Coursera*, *Udacity* or *edX*. These courses are often called x-MOOCs (Rodriguez, 2013). Other type of MOOCs – known as c-MOOCs – are loosely structured and allow learners to use a range of different online tools, such as blogs, *Twitter*, social bookmarking, feed readers and web conferencing (Fini, 2009).

This study was carried out in a context where formal higher education courses were opened up for external participants. These courses differentiated from typical c-MOOCs by having a more predefined structure and a smaller number of participants. Both the university students and the external participants used their personal blogs to submit course assignment and to participate in discussions. The moderate number of participants (under 50) allowed the course facilitator to follow and interact with every learner. Due to the smaller number of participants, a smaller variety of online tools was used. The authors propose however, that some of the results can be applied in all types of online courses with blogs.

Critical issues in blog-based courses

Earlier research identified several critical issues in the use of blogs in learning. These have been identified as fragmented discussions, the lack of coordination structures, weak support for awareness, and the danger of over-scripting.

The conversation used in blogs differs from online forums and mailing lists in several ways. Firstly, there is a problem with the distributed and fragmented nature of blog discussions (Efimova & de Moor, 2005) that may slow down the pace of conversation. Responses may be posted as comments to the original post or as separate posts in another blog. Thus a discussion can take place in an ecosystem of blogs rather than in a single blog. In forum discussions, people will easily notice new or active threads. In a distributed group of blogs, people may only visit or subscribe to a selection of blogs. Sometimes an interesting conversation topic is noticed only when other bloggers link to it. Xie, Ke, and Sharma (2008) concluded that the lack of a central location for all blogs prevents students from learning from the blogging activities of other course participants. In a course setting where participants prefer different communication tools, conversations started in blogs may move to other communication channels. Expressed in a different way by Kop, Fournier, and Mak (2011), “too much freedom in choice of tools unnecessarily fragments the conversation unless other tools are used to recombine the process” (p. 86).

Secondly, there is a problem with the lack of structure for coordination, also called *articulation*, that is the process of managing dependencies among activities (Malone & Crowston, 1994). Cooperative work that involves multiple actors requires that activities are coordinated, scheduled, aligned, meshed, integrated, etc. (Schmidt & Simone, 1996). Enrolling in the course, managing assignments and getting an overview of learner progress are examples of articulation that require coordination mechanisms.

Thirdly, coordination is related to awareness support mechanisms, typically implemented as a notification system that provides information about the presence, tasks, and actions of collaborators. Social awareness includes online presence and connections between actors, action awareness focuses on individual actions, and activity awareness deals with long-term joint endeavours directed at major goals (Carroll, Neale, Isenhour, Rosson, & McCrickard, 2003).

The genre of blog-based courses includes the scenario of a teacher writing assignment specifications to his/her blog and students writing responses to these assignments in their blogs. The students are expected to participate in collaborative knowledge building by commenting on and linking to the blog posts of each others. This requires the teacher to plan the tasks and the expected collaboration in the course. For instance, scripting can be used to coordinate these learning activities (O’Donnell & Dansereau, 1992). A script defines how students should form groups, how they should interact and collaborate, and how they should do the assignments. The main components of pedagogical scripts are: (a) task definition, (b) group definition, (c) distribution, (d) mode of interaction, and (e) timing (Dillenbourg, 2002). A coordination mechanism should support the implementation of scripts in online courses. However, too rigid coordination may result in over-scripting the course and in turn may disturb natural interactions and problem solving processes, increase the cognitive load of learners, force teacher-controlled learning processes, and impede learners from establishing and achieving their own learning goals (Dillenbourg, 2002).

Regardless of these challenges, the positive aspects and the potential benefits of using blogs in online courses are remarkable. Open learning with blogs supports learner-centeredness, active participation of students, and increased ownership of personal and group learning. While blogs are by nature a learner-centered medium in education, it is important to look also at the teachers’ perspective. Some of the recent research emphasises the importance of awareness tools for teachers. For instance, Dillenbourg et al. (2011) suggest that the design of learning tools should not focus only on individual learners and groups, but also on usability at the classroom or course level where teachers have to orchestrate multiple learning activities within a variety of real life constraints. Rodríguez-Triana, Martínez-Monés, Asensio-Pérez, and Dimitriadis (2014) point out that teachers need awareness tools to adjust their pedagogical scripts according to the progress of the learning process.

Research questions and the structure of the paper

Our study focuses on the teachers’ perspective in open learning with blogs. This paper addresses the following four interlinked research questions (RQ 1–4) and design challenges. How and to what extent can an online tool:

1. combine and present the fragmented discussions in blog-based courses?
2. provide coordination structures for managing blog-based courses?
3. provide a notification system for supporting awareness of learners and facilitators?
4. prevent over-scripting while providing sufficient coordination?

The rest of the article is divided into five sections. The second section introduces the design and implementation of *EduFeedr*. The third section provides an overview of the research methodology. This is followed by the analysis of the results and discussion of the findings. The article ends with the conclusions drawn from the study.

Design and implementation of *EduFeedr*

The design process

In order to address the research questions and design challenges summarised in the previous section, the authors have designed and developed a prototype of an online learning tool referred to as *EduFeedr*. The design process of *EduFeedr* follows a research-based design approach that is based on four iterative stages: (a) contextual inquiry, (b) participatory design, (c) product design, and (d) the development of software prototype as hypothesis, where the prototype aims to answer certain challenges recognised in earlier phases of research (Leinonen, Toikkanen, & Silfvast, 2008).

In the contextual inquiry phase, 4 blog-based courses were organised in which the authors tested various approaches for coordinating the learning activities (wikis, generic feed readers, etc.). The use of multiple coordination tools that were not directly integrated introduced a considerable amount of additional work for the facilitator. This experience helped to define the design challenges and requirements for coordinating blog-based courses. Based on the research questions, the following initial design requirements were decided: (a) the system should aggregate information from blogging platforms using open standards (RSS, *Atom*); (b) the system should not require any special plug-in in student blogs; (c) the scope of the system should be limited to aggregating and annotating the feeds from the blogs and visualising the process of knowledge building; (d) only the facilitator should be required to have a user account in the system to modify course settings; and (e) anyone should have *read* access to the aggregated course content. Design requirement (a) is related to combining the fragmented discussions (RQ 1). Requirement (c) is linked both to providing coordination structures (RQ 2) and supporting awareness (RQ 3). Requirements (b), (d) and (e) are general design requirements in order to keep the architecture of the system open and lightweight.

In the participatory design phase, the scenario-based design method (Carroll, 2000) was used to gather user feedback for the initial design ideas. A scenario-based design approach requires the designers to focus on people's activities and envision how these activities could be supported by software. The authors wrote six short scenarios regarding the use of *EduFeedr*: (a) first experience with *EduFeedr*, (b) posting a response to the assignment in the student blog, (c) exploring the connections between student blogs, (d) setting up course feeds, (e) archiving course posts and comments, and (f) using the offline client. An example scenario about exploring the connections between the blogs is presented in Figure 1.

> John has been using *EduFeedr* for a few weeks. For him, the most exiting feature is a way of presenting connections between the blogs. *EduFeedr* has a visualisation in which all the blogs are displayed as nodes. Lines between the nodes show the links between the blog posts. All the students have linked to the course blog. Some of the student blogs have a lot of connections while others have not been so active.
>
> It is possible to switch on a different view and see who has commented on which blog. This time, John finds out that some student blogs have actually received more comments than his blog.
>
> The same information is also displayed as a table in which it is easy to see how many pingbacks and comments each participant has made. *EduFeedr* has also aggregated all the comments. It means that John can see all the comments that one particular student has made on a same page without visiting all the blogs. This will save him a lot of time because commenting is part of his grading scheme and students get points for that.

Figure 1. Example scenario: Exploring the connections between student blogs

A list of questions was compiled for each scenario in order to guide the discussion. The scenarios were evaluated in two design sessions with 5 university teachers who had used blogs in their courses. In the design session, each participant received a sheet of paper with a written scenario. After the participants had read the scenario, the designer facilitated a discussion based on the guiding questions. The process was repeated for all six scenarios.

In the product design phase, the authors defined use cases and basic interaction by writing user stories (Cohn, 2004) and creating paper prototypes (Snyder, 2003). User stories capture a software requirement from the end user perspective in one or few sentences. In total, 48 user stories were written. The design team evaluated the user stories and paper prototypes internally. Two teachers were involved in discussing the paper prototypes. Developing user stories and paper prototypes in parallel helped to identify missing functionalities and to clarify details. Some initial paper prototypes are presented in Figure 2.

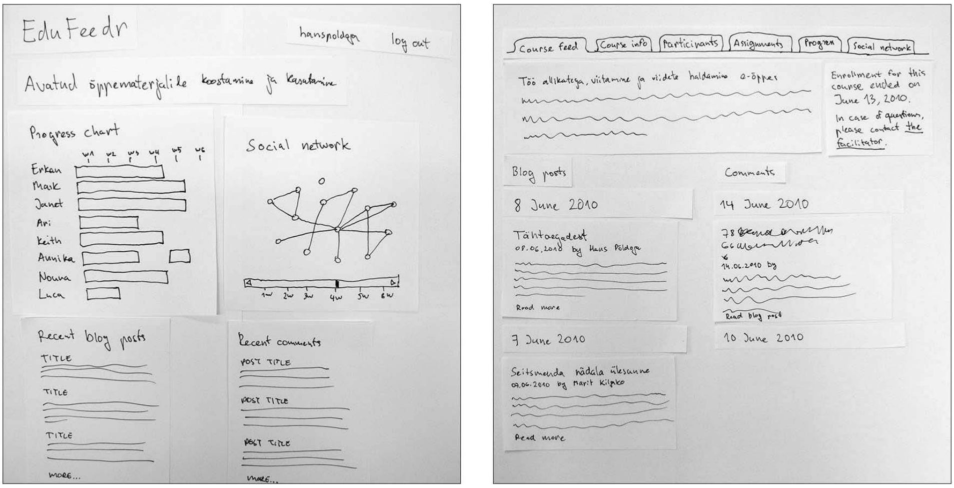


Figure 2. Initial paper prototypes of the course front page

The final phase of research-based design is the development of a software prototype as a hypothesis. In this study, the hypothesis is that the coordination of blog-based courses and participants' awareness could be improved by using a web-based tool that aggregates, structures and presents the learning activities that take place in learners' personal learning environments. The software prototype that aims to address the challenges is the *EduFeedr*, a web-based tool for open learning with blogs.

Implementation of *EduFeedr*

EduFeedr enables anyone to view the aggregated information from the courses. Facilitators need a user account only for managing the course settings and accessing contact information of learners. Each course is divided into six sections: (a) course feed, (b) course information, (c) participants, (d) assignments, (e) progress, and (f) social network. The course feed page combines the fragmented discussions by presenting recent posts and comments from the participants' blogs (see Figure 3).

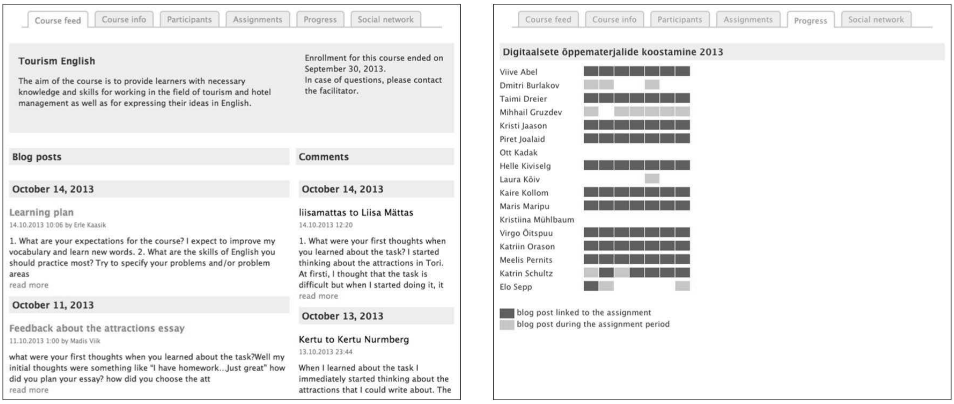


Figure 3. User interface of *EduFeedr*: Course feed page (left) and progress page (right)

EduFeedr provides coordination structures for managing the course participants and assignments. Learners can enrol in the course by submitting the address of their blog. The list of participants can be exported in various formats: vCard for address book, outline processor markup language (OPML) for feed readers, and spreadsheet for grading the assignments. Assignment specifications are written and published by the facilitator as blog posts in the course blog. Blog posts containing assignment specifications have to be specified in *EduFeedr* together with a due date. If a learner's post includes a link to the assignment specification in the course blog, the system will recognise it as a submission to the assignment. As a backup strategy, the system relies on the posting date to connect assignments and submissions.

In order to raise participants' awareness, *EduFeedr* provides a progress chart that displays submitted assignments (see Figure 3) and a social network visualisation that connects learners who have commented on or linked each other's posts. The social network data can be exported in tab-separated format for using in other visualisation tools.

EduFeedr leaves a reasonable amount of flexibility in scripting the learning activities. Tasks are defined in the facilitator's blog posts. Learners may choose their personal tools to form smaller groups, distribute work and interact with their peers. Only the final outcome must be submitted as a blog post. Learners may also use shared group blogs instead of personal blogs in *EduFeedr*. This flexibility allows users to vary and improvise their plans during the course. Table 1 summarises how the critical issues of blog-based courses were addressed in *EduFeedr*.

Table 1
Addressing the critical issues of blog-based courses in EduFeedr

Issue	Addressing the issue in *EduFeedr*
Fragmented discussions	Course feed page displays recent blog posts and comments
The lack of coordination structures	Learners can self-enroll in the course Learners can add their blog to *EduFeedr* for aggregation Facilitators can manage course participants Facilitators can manage assignments
Weak support for awareness	Progress page displays learners' submissions for assignments Social network page displays social network of learners
The danger of over-scripting	Facilitators post blogs as pedagogical scripts to which the learners are expected to respond in their own blog in their own way Learners have the flexibility to use other social media tools in addition to blogs and *EduFeedr*

Technically, *EduFeedr* is developed as a plug-in for the *Elgg* social networking engine. The *Elgg* framework provided the developers with user management and plugin architecture. *EduFeedr* operates as a front end that displays aggregated course data from the local database. Aggregation of blog posts and comments is handled by a separate web service. Various open-source libraries such as *SimplePie*, *JSViz*, and *NuSOAP* have been used. The source code is available under the *GNU General Public License*.

Related systems

There are a number of similar systems for coordinating blog-based learning environments. *gRSShopper* is aggregator and newsletter software that has been used in several c-MOOCs (Downes, 2010). The system aggregates all the blog posts that contain the course tag and enables the facilitator to compile a daily newsletter based on selected blog posts and Twitter tweets. *eMUSE* is a learning environment that can aggregate content from various social media platforms such as *Blogger*, *Delicious*, *Twitter*, *YouTube*, *SlideShare*, *MediaWiki*, and others (Popescu, 2014). The instructor can view different visualisations showing student progress and grade their assignments. *StepUp!* has also focus on visualisations that display the number of social media artefacts (blog posts, comments and tweets) and the time spent on various learning activities (Santos, Verbert, Govaerts, & Duval, 2013). There have been attempts to add blog aggregation to learning management systems, such as the *BIM* blog aggregation module for *Moodle* (Jones, 2013). Relying only on RSS feeds limits the communication between the blogs and the course management tool. *LePress* (Tomberg, Laanpere, Ley, & Normak, 2013) and *Dippler* (Laanpere, Pata, Normak, & Põldoja, 2014) have addressed this issue by developing a special plug-in for learners using *WordPress* blogs. This enables two-way communication that may include privately submitted assignments, private feedback, and grading. On the other hand, architectures that require a special plug-in in learners' blogs are not suitable for open online courses in which learners typically use free blog hosting services that do not allow the installation of additional plug-ins. In addition to syndication feeds, *eMUSE* and *StepUp!* use application programming interfaces (API) of *Twitter* and other systems to aggregate additional content. Table 2 presents the comparison of related systems, their aggregation architecture, supported blogging services, and coordination features.

Table 2
Comparison of related systems

System	Aggregation architecture	Supported services	Coordination features
EduFeedr	Syndication feeds	*WordPress*, *Blogger*	Courses, assignments, visualisations
gRSShopper	Syndication feeds	Any blogging platform	Newsletters, archive
*eMUS*E	Syndication feeds, service APIs	*Blogger*, *MediaWiki*, *Delicious*, *Twitter*, *YouTube*, *Picasa*, *SlideShare*	Courses, visualisations, grading
BIM	Syndication feeds, plugin for *Moodle*	Any blogging platform	Assignments, grading
StepUp!	Syndication feeds, service APIs	Any blogging platform, *Twitter*, *Toggl*	Courses, visualisations, time tracking, Open Badges
LePress	Plugin for *WordPress*	*WordPress*	Courses, assignments, grading
Dippler	Plugin for *WordPress*	*WordPress*	Courses, assignments, learning resources, competences, grading

Among these systems, *gRSShopper* is the closest to *EduFeedr*, since both systems are designed for supporting open online courses. However, *gRSShopper* does not support the management of assignments and lacks visualisations of learning activities. Currently, the *EduFeedr* system focuses only on aggregating blog posts and comments, while some other systems aggregate other types of content as well. Some of the visualisations available from *eMUSE* and *StepUp!* could serve as examples for developing additional visualisations for *EduFeedr*.

Methods

In the design phase, this study employed a number of interaction design methods such as scenario-based design, user stories, and paper prototyping. An agile software development methodology was followed, in which the software is divided into incremental functional versions that can be released frequently. This allowed the system to be tested in real courses with real participants and to gather both quantitative and qualitative data to guide the design process and the evaluation study.

This paper presents the results from the use of two instruments to evaluate the latest version of *EduFeedr*: (a) a survey with learners and facilitators who have used the system recently, and (b) an analysis of usage based on *Google Analytics*. The survey method was chosen because the authors wanted to collect data from users in other institutions and countries in addition to the feedback from learners in their own courses. The survey data and the *Google Analytics* data were used in conjunction with each other to corroborate interpretations made from them. In practice, the data from *Google Analytics* has also guided the design of the survey.

Participants

It was decided to forward the survey to learners who had participated in a course through *EduFeedr* during the previous year (N = 173) and facilitators who had run courses in *EduFeedr* during 2 previous years (N = 13). A total of 61 responses were received from learners and 8 responses from facilitators. Of these, 3 learners and 1 facilitator completed the survey only partially, but the incomplete data gathered from them was also used when possible. The learners who responded had participated in 10 different courses. The majority of the respondents had participated in master level courses (N = 39), but there were also 11 bachelor students, 4 respondents from an in-service teacher-training course, and 5 respondents from an open online course. 60% of the learners who responded were female and 40% male. The average age of the learners was 33.5 years (SD = 10.9). Of the facilitators, 5 were female and 2 were male. The average age of the facilitators was 39.3 years (SD = 6.8). A total of 77% of the learners had used *EduFeedr* within the last 6 months. During the course, 68% of the learners visited *EduFeedr* at least once each week. A total of 60% of the learners had participated in only one course in *EduFeedr*, 8% had taken two courses and 32% had experience from three or more courses. The majority of the respondents also had experience using other online learning platforms. A total of 93% of the learners had experience with learning management systems, 58% were using *Moodle* at least on a monthly basis.

Survey instrument and data collection

A web-based survey was divided into four sections: (a) critical issues and important learning activities in blog-based courses, (b) support for these learning activities in *EduFeedr*, (c) technology acceptance of *EduFeedr*, and (d) background information about the respondents. In the first three sections, the respondents were required to rate a number of statements on a 7-point Likert scale. Based on the literature review and courses carried out using EduFeedr, the authors identified 16 important learning activities in blog-based courses. The relationships between critical issues and learning activities in blog-based courses are presented in Figure 4. Some of the learning activities are clearly related to one of the issues while others are related to several issues. The survey contained a different set of activities for learners and for facilitators. Activities related to following the course discussions (A1–A4) were the same for all respondents. Learners' survey included activities related to awareness (A5–A10), while the facilitators had activities related to managing the course (A11–A16). The background information section included various types of questions related to demography, the frequency of using *EduFeedr* and previous experience with online learning. Considering the differences in the learners' and facilitators' questionnaire, the reliability was calculated separately for both survey instruments. The Cronbach's alpha for the learners' survey indicated a high internal consistency (α = 0.908). Due to the smaller number of respondents, the facilitators' survey had an acceptable internal consistency (α = 0.718).

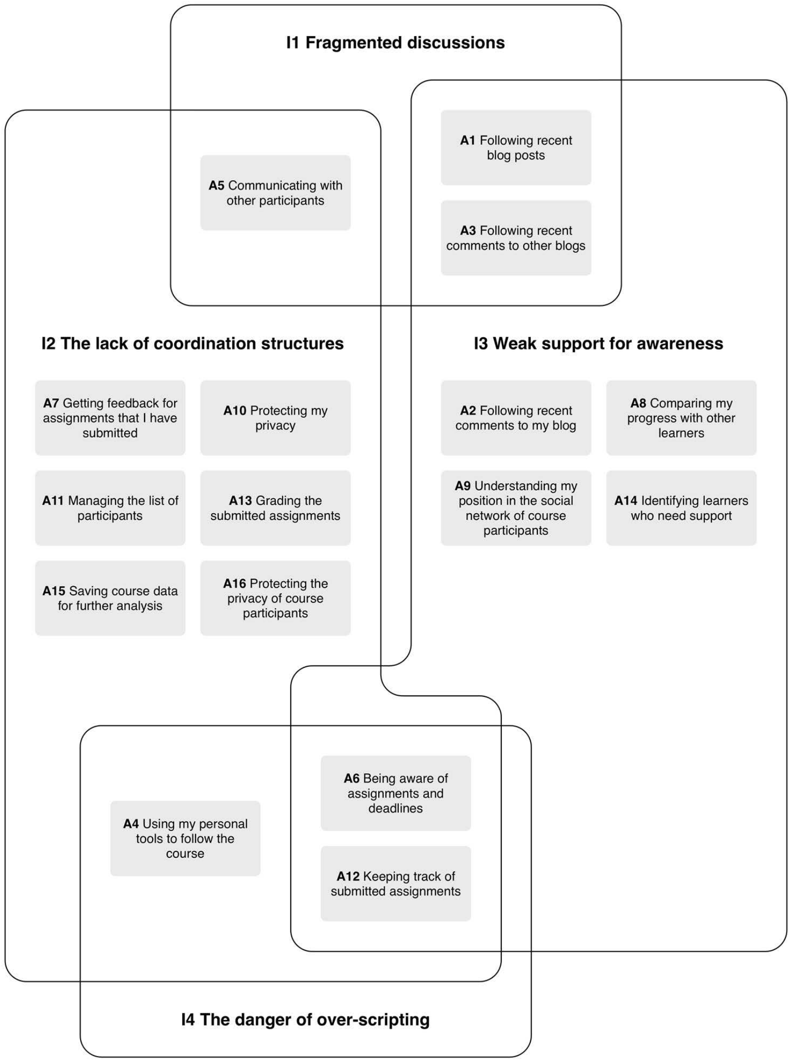


Figure 4. The relationships between critical issues and learning activities

Analysis

The means (*Ms*) and standard deviations (*SDs*) were calculated for each Likert scale statement for learners, facilitators, and all respondents. In order to depict the variation of answers, quartiles were calculated and box plot charts were created showing the sample minimum, lower quartile, median, upper quartile, and sample maximum.

Results

Critical issues in blog-based courses

Critical issues in blog-based courses were rated from *not critical at all* (1) to *very critical* (7) (see Figure 5). The most critical issues were the fragmentation of discussions (M = 4.45; SD = 1.61) and the awareness of learning activities (*M* = 4.16; *SD* = 1.84). All four issues were found to be more critical by the facilitators than by the learners. The most noticeable difference between learner and facilitator answers was related to I2. The lack of coordination tools was seen to be a more critical issue by the facilitators (*M* = 4.88; *SD* = 1.81) than by the learners (*M* = 3.79; *SD* = 1.84).

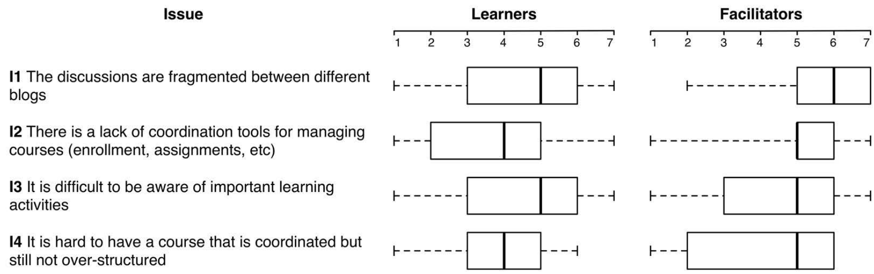


Figure 5. Critical issues in blog-based courses

Importance of learning activities in blog-based courses

The importance of common learning activities in blog-based courses was rated from *not important at all* (1) to *very important* (7) (see Figure 6). Activities related to course assignments were rated as the most important. For learners, the two most important activities were "Being aware of assignments and deadlines" (*M* = 6.62; *SD* = 0.69) and "Getting feedback for assignments that I have submitted" (*M* = 6.59; *SD* = 0.76). Also, the facilitators rated "Keeping track of submitted assignments" as the most important activity (*M* = 6.25; *SD* = 1.04). This can be explained by the fact that most of the respondents were from formal higher education courses. The least important activities for learners were "Understanding my position in the social network of course participants" (*M* = 4.21; *SD* = 1.75) and "Following recent comments to other blogs" (*M* = 4.69; *SD* = 1.63). The facilitators on the other hand found "Following recent comments to other blogs" to be more important activity (*M* = 5.63; *SD* = 0.74). For facilitators, the less important activities were "Saving course data for further analysis" (*M* = 5.25; *SD* = 1.16), "Protecting the privacy of course participants" (*M* = 5.25; *SD* = 1.39), and "Using my personal tools to follow the course" (*M* = 5.13; *SD* = 1.73).

Support for important learning activities in EduFeedr

The respondents also rated *EduFeedr* on how it supports the learning activities listed in Figure 6. The statements regarding how *EduFeedr* supports important learning activities were rated from *strongly disagree* (1) to *strongly agree* (7). Both the facilitators and learners agreed that *EduFeedr* enables them to follow recent blog posts (*M* = 5.66; *SD* = 1.57) and comments to other blogs (*M* = 5.15; *SD* = 1.68). Learners also tend to agree that *EduFeedr* helps them to be aware of assignments and deadlines (*M* = 5.25; *SD* = 1.58) and to compare their progress with other learners (*M* = 5.08; *SD* = 1.69). The facilitators agreed that *EduFeedr* enables them to manage the list of participants (*M* = 5.86; *SD* = 0.69) and to keep track of submitted assignments (*M* = 5.57; *SD* = 1.13). The facilitators tend to agree less that *EduFeedr* makes it easier to grade submitted assignments (*M* = 4.14; *SD* = 1.57) and to identify learners who need support (*M* = 4.29; *SD* = 1.50). Both the learners and the facilitators tend to disagree that *EduFeedr* enables them to protect their privacy (*M* = 3.64; *SD* = 1.39) or the privacy of course participants (*M* = 3.57; *SD* = 1.51). We recommend the participants to use an alias or protect their blog posts with a password if they do not feel comfortable with open blogging. The facilitators also tend to disagree that *EduFeedr* facilitates saving course data for further analysis (*M* = 3.86; *SD* = 0.90). Currently it is possible to export the social network data. Both the facilitators and the learners only somewhat agreed that *EduFeedr* enables them to use personal tools for following the course (*M* = 4.43, *SD* = 1.31). It is possible to download an OPML file that can be used to subscribe to all participants' blogs. One of the respondents requested that *EduFeedr* should provide a combined RSS feed that includes all posts in the course.

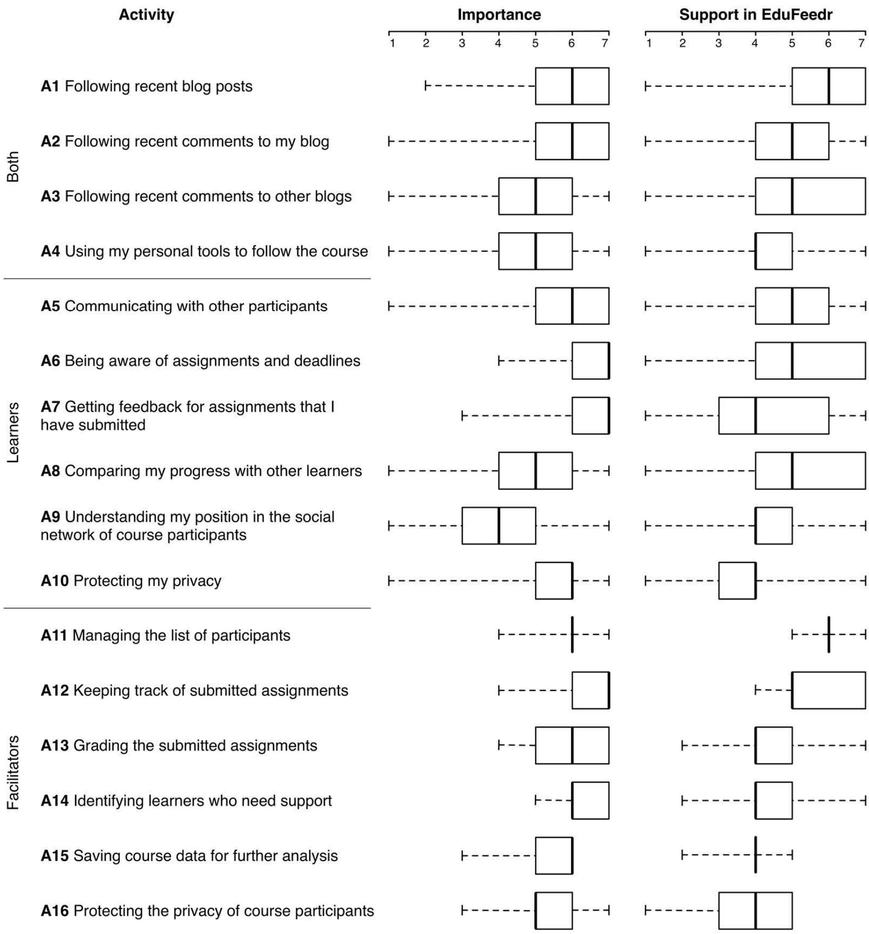


Figure 6. Learning activities and their support in *EduFeedr*

Technology acceptance of *EduFeedr*

The acceptance of *EduFeedr* based on the extended technology acceptance model (TAM2) (Venkatesh & Davis, 2000) was also studied. Only sections relevant to *EduFeedr* were chosen from the TAM2 model (perceived usefulness, perceived ease of use, output quality, result demonstrability). TAM2 statements were rated from *strongly disagree* (1) to *strongly agree* (7), as recommended by Venkatesh and Davis (2000). Therefore, a similar 7-point scale was used in other questions. Learners' and facilitators' responses are compared in Figure 7. The highest rated statements were those regarding the perceived usefulness and perceived ease of use: "I find *EduFeedr* to be useful in my learning (job)" (M = 5.13; SD = 1.70), "Interacting with *EduFeedr* does not require a lot of my mental effort" (M = 5.53; SD = 1.32), and "I find *EduFeedr* to be easy to use" (M = 5.37; SD = 1.54). For almost all the statements, the mean response from the facilitators was higher than from the learners. The only exception was the statement "Interacting with *EduFeedr* does not require a lot of my mental effort", which was rated slightly higher by the learners.

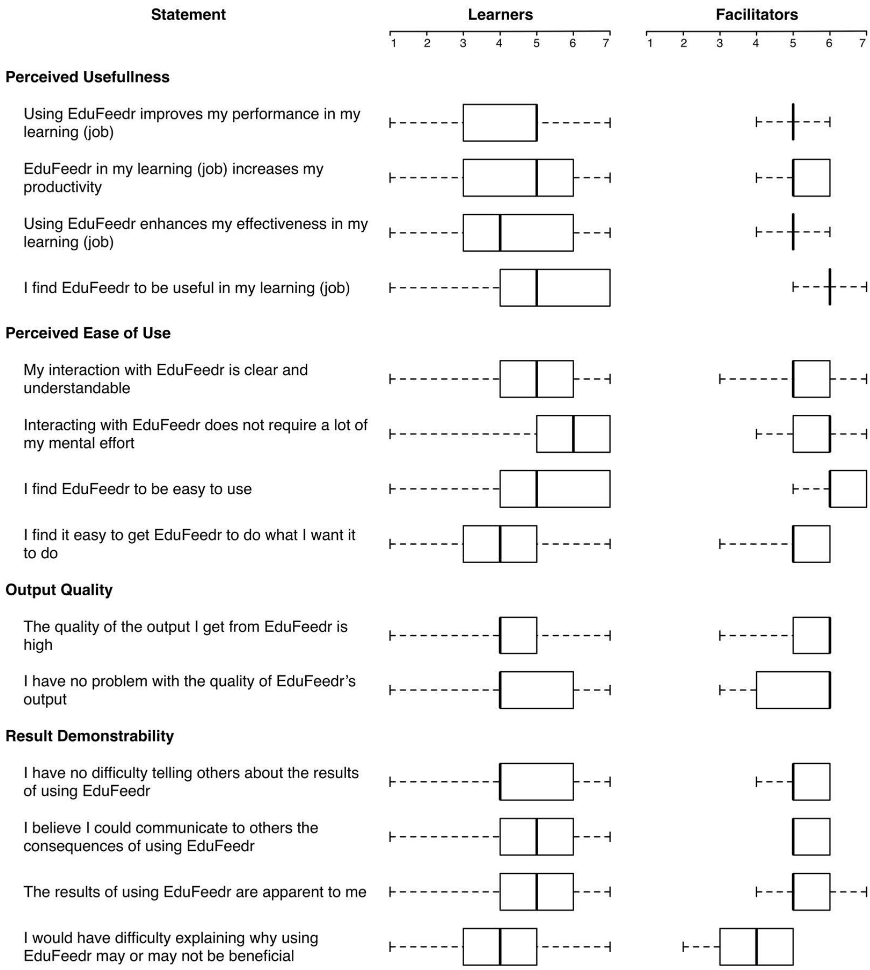


Figure 7. Technology acceptance of *EduFeedr*

Web analytics of *EduFeedr*

In order to confirm the findings of the survey, *Google Analytics* was used to compare the In-Page Analytics from 10 courses in which the respondents participated. The *Google Analytics* data included all visitors on the courses, as it was not possible to receive separate data about visitors who had answered the survey. In-Page Analytics indicate the percentage and number of clicks for each visited link. Figure 8 shows the In-Page Analytics view for the course feed page in one of the courses. In this particular course, the progress page was the most visited section (15% of clicks) followed by the course feed page (10%) and course information page (4.8%). Fixed menu items received 41.7% of clicks on that page, with the remainder being for the dynamic content – blog posts and comments.

In total, the front pages of these courses received 9445 page views during an 8-month period. The average *bounce rate* for course front pages was 24.2%. The bounce rate refers to the percentage of visitors who leave the site after visiting only the entrance page (Booth & Jansen, 2009). It may be considered a good result since 3 visitors out of 4 continue browsing the course through *EduFeedr*. On average, visitors spent 1 minute and 9 seconds reading the recent blog posts and comments on the course feed page; the average total length of visit to *EduFeedr* was 4 minutes and 58 seconds. A total of 13.7% of visitors continued from the front page to the progress page and 12.6% of visitors went to the participants' page. It was also noticed that the usage pattern changed according to the learner's experience with *EduFeedr*. In courses where the learners had previous experience with *EduFeedr*, more than 20% of visitors continued to the progress page to compare their progress with other learners and to access the submitted assignments. The progress page was also the second most visited section in the 10 courses (N = 4989). The participants' page (N = 2712), assignments page (N = 2150) and course information page (N = 1416) received fewer views. The least visited section was the social network visualisation page (N = 696).

Figure 8. In-Page Analytics page in Google Analytics highlighting the percentage of clicks for each link

Comparing the results of the survey and web analytics

Usage statistics from *Google Analytics* support the main findings of the survey. The survey indicated that *EduFeedr* enables learners and facilitators to follow recent blog posts and comments to other blogs (see activities A1 and A3 in Figure 6). This is supported by the data from *Google Analytics,* which shows that the typical visitor spent more than one minute reading the beginnings of recent blog posts and comments on the course feed page. The survey results suggest that the learners have found it useful to compare their progress with other learners (see activity A8 in Figure 6). This is supported by the web analytics data that shows a high number of visits to the progress page. In the survey, the learners rated the awareness of assignments and deadlines more important than communicating with other participants. However, web analytics data shows that the participants' page was visited more often than the assignments page. The survey showed that the learners found the social network visualisation less useful (see activity A9 in Figure 6). Web analytics data also indicated that the social network page was the least visited section.

Discussion

This study contributes to research on the use of blogs in education and provides insight into the further design and development of tools for open learning with blogs. The findings show that both learners and facilitators of open online courses consider the activities related to submitting assignments and providing feedback to be the most important. Although this may be influenced by the fact that in the majority of the courses, the students were evaluated and graded based on their blog posts, the results exhibit some characteristics of open online courses using blogs. In these types of courses, both learners and facilitators expect a high level of social interaction among the participants. These results are in line with a number of studies that emphasise the motivating and compelling effect of assessed assignments on blogging (Gray, Thompson, Sheard, Clerehan, & Hamilton, 2010; Henderson, Balatti, Knight, & Haase, 2010) and the usefulness of reading other learners' ideas and getting feedback on one's own blog posts (Churchill, 2009; Ellison & Wu 2008). The study also indicates some areas where online tools for courses using blogs could be improved. These are discussed in more detail below.

While the learners and the facilitators were positive about how *EduFeedr* combines the fragmented discussions, some relatively minor changes to the current features could improve the tool. The course feed page, for example, currently displays a fixed number of the most recent blog posts and comments. This has not been an issue in the current courses because the average number of course participants has been 21. However, it would become an issue in larger courses with very active discussions. This issue could be resolved by loading additional content dynamically when the user is scrolling down. The course feed page could also provide combined RSS feeds for all posts and comments.

The ability of *EduFeedr* to help in the coordination of the course was evaluated relatively high by both the learners and the facilitators. However, a number of improvements could be made to the coordination features as well. *EduFeedr* relies solely on the data that is aggregated from Atom feeds. In several cases, this data is not sufficient. The two most typical examples of insufficient data are: (a) the link to the assignment specification is missing from the learners' blog post; (b) the learner who wrote a comment was not logged in to a blogging service. As a solution to the problem, a feature has been designed that allows facilitators to connect blog posts with assignments and comments with an author, using a simple drop-down menu. Having complete data about submitted assignments and written comments would improve the browsing and visualisations of course data. Furthermore, learner profiles that aggregate all the blog posts and comments that the learner has written in the course, would help the coordination of the course. When compared to other features, the facilitators were less positive about how *EduFeedr* supports grading. In order to support grading the assignments, *EduFeedr* provides a grading table that the facilitators can download and utilise in their preferred spreadsheet application. Grading could also be improved by having the ability to categorise and annotate the blog posts. For example, Chu, Chan and Tiwari (2012) have proposed a categorisation scheme in which blog posts can be divided into 4 themes (cognitive, metacognitive-reflective, collaborative/social, affective) and 10 sub-themes. This kind of categorisation would provide a further option for browsing the blog posts, as well as helping in the coordination process and creating opportunities for learning analytics.

In regard to the awareness of learning activities, learners found the progress chart of *EduFeedr* to be most useful feature. Designing additional visualisations showing progress and relations of the learners in the course could be useful. For instance, one of the prototypes that the authors have created compares the number of written and received comments for each learner. Some facilitators have a practice of writing summaries of each assignment by reflecting on how the learners did with the assignment. To promote this good practice, *EduFeedr* could provide a word cloud visualisation (Gottron, 2009) that summarises the content of student posts for each assignment. Features such as these were found to be important in earlier studies as well. For instance, Miyazoe and Anderson (2011) have studied the effect of blog visualisations on student learning. Their study concludes that viewing the online performance of other learners can function as a self-regulatory mechanism and could produce improved learning outcomes.

Both the survey results and *Google Analytics* indicate that the learners and the facilitators found the current social network visualisation less valuable than other sections of *EduFeedr*. Larusson and Alterman (2009) have studied visualising students blogging activities in a course context where each learner had a blog. One of their visualisations is close to the social network graph in *EduFeedr*. However, their visualisation also allows highlighting interactions related to one student. This is useful when a large number of connections make the graph cluttered. Redesigning *EduFeedr*'s social network visualisation by adding different views and the ability to navigate to blog posts could provide additional value for learners and facilitators.

The relationship between scripting and awareness is a multifaceted issue that has been studied also in some recent research (Miller & Hadwin, 2015; Rodríguez-Triana et al., 2014; Tsovaltzi, Puhl, Judele, & Weinberger, 2014). Rodríguez-Triana et al. (2014) suggest a process in which monitoring of learner interactions is designed into pedagogical scripts and awareness tools can advice learners based on the collected data. In a simplified way, this process is followed also in *EduFeedr* (e.g., when learners are asked to include a link to the assignment specification in their blog post and decisions can be made based on progress visualisation). Tsovaltzi et al. (2014) studied how group awareness tools and argumentation scripts influence learning in *Facebook*. One of their results was that group awareness support of upcoming argumentative processes could be actually counterproductive for learning. Using argumentation scripts to guide the discussion in blogs would require a more rigid structure. For example, argument types could be specified in comments using hashtags. Miller and Hadwin (2015) discussed how using scripting tools together with group awareness tools could support regulation of collaboration. Combining scripting tools with blogs is an issue that needs further research. From the technical perspective, scripting tools cannot be easily integrated with free blog hosting services that are typically used in open online courses. Also, scripting tools often impose a more defined structure for the collaboration while blog posts and comments have a relatively simple structure. These issues may lead to a danger of over-scripting.

In the study, there are two limitations. First, the learners participating in the study had rather different levels of experience with *EduFeedr*. Some of the learners had participated in courses where all the features of *EduFeedr* were used extensively. Other learners took courses where the facilitator didn't specify assignments in *EduFeedr* and therefore fully lacked the progress chart that is one of the most visited pages in a typical *EduFeedr* course. Thus, the responses from learners who didn't use one of the most important features of *EduFeedr*, may have slightly distorted the overall results. Learners from courses where the assignments feature was used had slightly higher agreement with the statements "*EduFeedr* helps me to compare my process with other learners" ($M = 5.27$, for all learners $M = 5.08$) and "I find *EduFeedr* to be useful in my learning" ($M = 5.18$, for all learners $M = 5.05$). Secondly, the survey method itself is limited in research, which is partly aiming to serve design. In design research one needs also rich qualitative data that is gathered through user observations and interviews.

Conclusions

This paper addressed four research questions and design challenges that are crucial for designing online tools for open learning with blogs: (a) combining and presenting fragmented discussions, (b) providing coordination structures, (c) supporting awareness, and (d) preventing over-scripting of courses. These questions and challenges stem from the authors' own research as well as from their review of related research on using blogs in learning (Churchill, 2009; Kim, 2008; Sim & Hew, 2010). In order to study how and to what extent these challenges could be addressed in the design of an online learning tool, the prototype *EduFeedr* was designed and developed. A survey was conducted to research learner and facilitator perceptions on the importance of these challenges and related learning activities, as well as their satisfaction with how *EduFeedr* addresses these challenges. A total of 61 learners and 8 facilitators from 10 courses completed the survey.

The results of the study confirmed earlier research that identified the fragmentation of discussions and the awareness of learning activities as critical issues in blog-based courses (Kop et al., 2011; Xie et al., 2008). On the other hand, the lack of coordination structures and the danger of over-scripting, also reported as important in earlier studies (Dillenbourg, 2002), were not found to be that critical in this survey. Through the design process of *EduFeedr*, a number of solutions were found which addressed the issue of fragmentation of discussions. Indeed, learners and facilitators agreed that *EduFeedr* enabled them to follow recent blog posts and comments. Moreover, the *EduFeedr* design also addressed the lack of coordination structures, and supported awareness in open learning with blogs; learners and facilitators agreed that *EduFeedr* enabled them to monitor the submission of assignments and compare progress with other learners. Usage data from *Google Analytics* supported the survey findings. However, it was concluded that the danger of over-scripting the learning activities is a more comprehensive pedagogical issue that cannot be addressed solely by the design of online learning tools.

The main contribution of this study is to highlight the issues that arise in open learning with blogs and to explore ways of addressing these issues in tool design. The authors consider the support of increased awareness on the part of learners and facilitators to be the most promising direction for future research. This is related both to information visualisation and learning analytics of blog-based learning environments. *EduFeedr* would benefit from additional visualisations that help to compare learner activity in blog-based discussions. More evaluations are needed on the actual use of *EduFeedr* in different types of blog-based courses. Also, the danger of over-scripting is a complex issue that needs further study.

Acknowledgement

This paper is dedicated to the memory of co-author Erik Duval, who passed away on March 12th, 2016.

References

Berners-Lee, T. (2010). Long live the web: A call for continued open standards and neutrality. *Scientific American, 303*(6), 80–85. Retrieved from http://www.scientificamerican.com/article/long-live-the-web/

Booth, D., & Jansen, B. J. (2009). A review of methodologies for analyzing websites. In B. J. Jansen, A. Spink, & I. Taksa (Eds.), *Handbook of Research on Web Log Analysis* (pp. 141–162). Hershey, PA: IGI Global. doi:10.4018/978-1-59904-974-8.ch008

Cakir, H. (2013). Use of blogs in pre-service teacher education to improve student engagement. *Computers & Education, 68*, 244–252. doi:10.1016/j.compedu.2013.05.013

Carroll, J. M. (2000). *Making use: Scenario-based design of human-computer interactions*. Cambridge, MA: The MIT Press.

Carroll, J. M., Neale, D. C., Isenhour, P. L., Rosson, M. B., & McCrickard, D. S. (2003). Notification and awareness: synchronizing task-oriented collaborative activity. *International Journal of Human-Computer Studies, 58*(5), 605–632. doi:10.1016/S1071-5819(03)00024-7

Chu, S. K.W., Chan, C. K.K., & Tiwari, A. F.Y. (2012). Using blogs to support learning during internship. *Computers & Education, 58*(3), 989–1000. doi:10.1016/j.compedu.2011.08.027

Churchill, D. (2009). Educational applications of Web 2.0: Using blogs to support teaching and learning. *British Journal of Educational Technology, 40*(1), 179–183. doi:10.1111/j.1467-8535.2008.00865.x

Cohn, M. (2004). *User stories applied: For agile software development*. Boston, MA: Addison-Wesley.

Dabbagh, N., & Kitsantas, A. (2012). Personal Learning Environments, social media, and self-regulated learning: A natural formula for connecting formal and informal learning. *The Internet and Higher Education, 15*(1), 3–8. doi:10.1016/j.iheduc.2011.06.002

Dillenbourg, P. (2002). Over-scripting CSCL: The risks of blending collaborative learning with instructional design. In P. A. Kirschner (Ed.), *Three worlds of CSCL: Can we support CSCL?* (pp. 61–91). Herleen: Open Universiteit Nederland.

Dillenbourg, P., Zufferey, G., Alavi, H., Jermann, P., Do-Lenh, S., Bonnard, Q., ... Kaplan, F. (2011). Classroom orchestration: The third circle of usability. In H. Spada, G. Stahl, N. Miyake, & N. Law (Eds.), *Connecting computer-supported collaborative learning to policy and practice: CSCL2011 Conference proceedings* (Vol. 1, pp. 510–517). Hong Kong: International Society of the Learning Sciences.

Downes, S. (2010). New technology supporting informal learning. *Journal of Emerging Technologies in Web Intelligence, 2*(1), 27–33. doi:10.4304/jetwi.2.1.27-33

Efimova, L., & de Moor, A. (2005). Beyond personal web publishing: An exploratory study of conversational blogging practices. *Proceedings of the 38th Hawaii International Conference on System Sciences* (p. 107a). Los Alamitos, CA: IEEE. doi:10.1109/HICSS.2005.118

Ellison, N. B., & Wu, Y. (2008). Blogging in the classroom: A preliminary exploration of student attitudes and impact on comprehension. *Journal of Educational Multimedia and Hypermedia, 17*(1), 99–122. Retrieved from http://www.editlib.org/p/24310/

Fini, A. (2009). The technological dimension of a massive open online course: The case of the CCK08 course tools. *International Review of Research in Open and Distance Learning, 10*(5), 1–26. Retrieved from http://www.irrodl.org/index.php/irrodl/article/viewArticle/643

Goktas, Y., & Demirel, T. (2012). Blog-enhanced ICT courses: Examining their effects on prospective teachers' ICT competencies and perceptions. *Computers & Education, 58*(3), 908–917. doi:10.1016/j.compedu.2011.11.004

Gottron, T. (2009). Document word clouds: Visualising web documents as tag clouds to aid users in relevance decisions. In M. Agosti, J. Borbinha, S. Kapidakis, C. Papatheodorou, & G. Tsakonas (Eds.), *Research and advanced technology for digital libraries* (Vol. 5714, pp. 94–105). Berlin: Springer. doi:10.1007/978-3-642-04346-8_11

Gray, K., Thompson, C., Sheard, J., Clerehan, R., & Hamilton, M. (2010). Students as Web 2.0 authors: Implications for assessment design and conduct. *Australasian Journal of Educational Technology, 26*(1), 105–122. Retrieved from http://ascilite.org.au/ajet/ajet26/gray.html

Henderson, L., Balatti, J., Knight, C., & Haase, M. (2010). Motivation and participation in learning blogs: challenging the role of assessment. In M. Vick (Ed.). *Teacher education for a sustainable future: Proceedings of the 2010 Australian Teacher Education Association national conference, 4-7 July 2010, Townsville, QLD, Australia* (pp. 1–7). Townsville: ATEA.

Jones, D. (2013, May 12). *BIM – Feed aggregation management and marking*. Retrieved from http://davidtjones.wordpress.com/research/bam-blog-aggregation-management/

Kim, H. N. (2008). The phenomenon of blogs and theoretical model of blog use in educational contexts. *Computers & Education, 51*(3), 1342–1352. doi:10.1016/j.compedu.2007.12.005

Kop, R., Fournier, H., & Mak, J. S. F. (2011). A pedagogy of abundance or a pedagogy to support human beings? Participant support on massive open online courses. *The International Review of Research in Open and Distance Learning, 12*(7), 74–93. Retrieved from http://www.irrodl.org/index.php/irrodl/article/view/1041

Laanpere, M., Pata, K., Normak, P., & Põldoja, H. (2014). Pedagogy-driven design of digital learning ecosystems. *Computer Science and Information Systems, 11*(1), 419–442. doi:10.2298/CSIS121204015L

Larusson, J. A., & Alterman, R. (2009). Visualizing student activity in a wiki-mediated co-blogging exercise. *Proceedings of the Extended Abstracts on Human Factors in Computing Systems* (pp. 4093–4098). New York, NY: ACM. doi:10.1145/1520340.1520623

Leinonen, T., Toikkanen, T., & Silfvast, K. (2008). Software as hypothesis: Research-based design methodology. *Proceedings of the Tenth Anniversary Conference on Participatory Design 2008* (pp. 61–70). Indianapolis, IN: Indiana University. Retrieved from http://dl.acm.org/citation.cfm?id=1795244

Malone, T. W., & Crowston, K. (1994). The interdisciplinary study of coordination. *ACM Computing Surveys, 26*(1), 87–119. doi:10.1145/174666.174668

McLoughlin, C., & Lee, M. J.W. (2007). Social software and participatory learning: Pedagogical choices with technology affordances in the Web 2.0 era. In R. J. Atkinson, C. McBeath, S. K. A. Soong, & C. Cheers (Eds.), *ICT: Providing choices for learners and learning. Proceedings of ascilite Singapore 2007* (pp. 664–675). Singapore: Nanyang Technological University. Retrieved from http://www.ascilite.org/conferences/singapore07/procs/mcloughlin.pdf

Miller, M., & Hadwin, A. (2015). Scripting and awareness tools for regulating collaborative learning: Changing the landscape of support in CSCL. *Computers in Human Behavior*, *52*, 573–588. doi:10.1016/j.chb.2015.01.050

Miyazoe, T., & Anderson, T. (2011). Viewing and participating: Blog visualization and its learning outcomes in blended learning. *Proceedings of the Professional Communication Conference (IPCC)* (pp. 1–9). Cincinnati, OH: IEEE. doi:10.1109/IPCC.2011.6087217

O'Donnell, A. M., & Dansereau, D. F. (1992). Scripted cooperation in student dyads: A method for analyzing and enhancing academic learning and performance. In R. Hertz-Lazarowitz, & N. Miller (Eds.), *Interaction in cooperative groups: The theoretical anatomy of group learning* (pp. 120–141). London: Cambridge University Press.

Oravec, J. A. (2003). Blending by blogging: Weblogs in blended learning initiatives. *Journal of Educational Media, 28*(2–3), 225–233. doi:10.1080/1358165032000165671

Popescu, E. (2014). Providing collaborative learning support with social media in an integrated environment. *World Wide Web, 17*(2), 199–212. doi:10.1007/s11280-012-0172-6

Rodriguez, O. (2013). The concept of openness behind c and x-MOOCs (massive open online courses). *Open Praxis, 5*(1), 67–73. doi:10.5944/openpraxis.5.1.42

Rodríguez-Triana, M. J., Martínez-Monés, A., Asensio-Pérez, J. I., & Dimitriadis, Y. (2014). Scripting and monitoring meet each other: Aligning learning analytics and learning design to support teachers in orchestrating CSCL situations. *British Journal of Educational Technology, 46*(2), 330–343. doi: 10.1111/bjet.12198

Santos, J. L., Verbert, K., Govaerts, S., & Duval, E. (2013). Addressing learner issues with *StepUp!*: An evaluation. In D. Suthers, K. Verbert, E. Duval, & X. Ochoa (Eds.), *Proceedings of the Third International Conference on Learning Analytics and Knowledge* (pp. 14–22). New York, NY: ACM. doi:10.1145/2460296.2460301

Schmidt, K., & Simone, C. (1996). Coordination mechanisms: Towards a conceptual foundation of CSCW systems design. *Computer Supported Cooperative Work: The Journal of Collaborative Computing, 5*(2–3), 155–200. doi:10.1007/BF00133655

Sim, J. W. S., & Hew, K. F. (2010). The use of weblogs in higher education settings: A review of empirical research. *Educational Research Review, 5*(2), 151–163. doi:10.1016/j.edurev.2010.01.001

Snyder, C. (2003). *Paper prototyping: The fast and easy way to design and refine user interfaces*. San Francisco, CA: Morgan Kaufmann.

Tomberg, V., Laanpere, M., Ley, T., & Normak, P. (2013). Sustaining teacher control in a blog-based personal learning environment. *The International Review of Research in Open and Distance Learning, 14*(3), 109–133. Retrieved from http://www.irrodl.org/index.php/irrodl/article/view/1397

Tsovaltzi, D., Puhl, T., Judele, R., & Weinberger, A. (2014). Group awareness support and argumentation scripts for individual preparation of arguments in Facebook. *Computers & Education, 76*, 108–118. doi:10.1016/j.compedu.2014.03.012

Venkatesh, V., & Davis, F. D. (2000). A theoretical extension of the technology acceptance model: Four longitudinal field studies. *Management Science, 46*(2), 186–204. doi:10.1287/mnsc.46.2.186.11926

Williams, J. B., & Jacobs, J. (2004). Exploring the use of blogs as learning spaces in the higher education sector. *Australasian Journal of Educational Technology, 20*(2), 232–247. Retrieved from http://ascilite.org.au/ajet/ajet20/williams.html

Xie, Y., Ke, F., & Sharma, P. (2008). The effect of peer feedback for blogging on college students' reflective learning processes. *The Internet and Higher Education, 11*(1), 18–25. doi:10.1016/j.iheduc.2007.11.001

Corresponding author: Hans Põldoja, hans.poldoja@tlu.ee

Please cite as: Põldoja, H., Duval, E. & Leinonen, T. (2016). Design and evaluation of an online tool for open learning with blogs. *Australasian Journal of Educational Technology, 32*(2), 64-81.

Publication 4

Põldoja, H., & Väljataga, T. (2010). Externalization of a PLE: Conceptual Design of LeContract. In *The PLE 2010 Conference Proceedings*. Barcelona: Citilab. Retrieved from http://pleconference.citilab.eu/cas/wp-content/uploads/2010/06/ple2010_submission_68.pdf

Externalization of a PLE: Conceptual Design of LeContract

Hans Põldoja, Tallinn University, Estonia – hans.poldoja@tlu.ee
Terje Väljataga, Tallinn University, Estonia – terje.valjataga@tlu.ee

Abstract

A Personal Learning Environment (PLE) can be understood as an individual's perception of the resources and activities in relation to a particular learning project. Such an understanding of the individual's PLE can be externalized by following a personal learning contract procedure. Individuals themselves set up their objectives, select potential resources and design their learning strategy. Implementations of the learning contract procedure have shown that individuals would benefit from having guidance for explicating their learning objectives, procedures and resources. Generic tools (such as weblogs) that are often used for writing learning contracts do not provide this kind of scaffolding.

In this paper we present the design process and conceptual design of LeContract tool, which attempts to support the personal learning contract procedure. LeContract provides structural templates that define important parts of the learning contract. During the learning project the contracts can be reviewed and the achievement of individual learning objectives can be evaluated.

1. Introduction

There are various interpretations of the PLE concept (e.g. Arenas 2008; Harmelen 2006; Kolas and Staupe 2007; Wilson et al. 2007; Atwell 2007). Most of the educators and researches tend to talk about PLEs as instruments typically associated with social media (Johnson and Liber 2008) an individual can choose and control. A mainstream understanding is that a PLE is either a single technological application (e.g. Netvibes, Weblog, Flock) hosted and partially controlled by institutions or a collection of them chosen by each individual, rather than the institution (Jones 2008).

Fiedler and Pata (2009) define a PLE as a collection of instruments, materials and human resources that an individual is aware of and has access to in the context of an educational project at a given point in time. Thus, they stress the importance of a relationship between an environment and an educational project. While an environment is understood generally as (constructed) conditions that surround an individual and provide a setting in which the individual operates, it becomes a learning environment when one wants to carry out a learning project (Väljataga and Laanpere, forthcoming). In this case the individual starts to perceive potential activities and (lack of) resources (natural objects; people; mental, physical and digital artefacts) of his/her environment in relation to a particular learning project at a given point in time. The particular learning project gives a meaning and awareness to the perceived resources that are located in the individual's learning environment. Although the dominant thinking of PLEs is related to web-based technology, the authors of this paper want to point out that a PLE does not necessarily have to make use of technological applications. However, as much of our activities and life are gradually moving to Web, technological means in one's PLE start to be more and more a variety of social media applications, providing possibilities to extend one's perceived environment.

In order to understand and analyze individual's perception of a particular learning environment, his/her mental model of it needs to be externalized and articulated. One of the potential tools that serve the purpose of externalizing individual's learning intentions with a perceived environment is a personal learning contract procedure (Harri-Augstein and Webb 1996). Personal learning contracts allow individuals to describe their objectives, (preferably set up by themselves), explicate the design and formation of their learning experiences as well as selection (perception) of potential resources according to a particular project. However, such an explication is often hard to achieve unguided. As many learning processes are inevitably required to be mediated by emerging networked technology, a suitable medium should be chosen. Implementations of the learning contract procedure into existing teaching and studying practices in formal higher education have shown that individuals would benefit from having guidance for explicating their learning objectives, procedures and resources. However, existing generic tools (such as weblogs), that could be considered as one option for writing down learning contracts, do not provide this kind of scaffolding. The deficiency is seen in lacking a clear structure. Furthermore, combining written learning contracts with chronological, but at the same time miscellaneous, posts makes it hard for involved actors to carry out learning related conversations, monitoring and reviewing. Thus, the authors of this paper believe that a special personal learning contract tool — LeContract — that can provide the necessary scaffolding for learners and facilitators in technologically mediated learning settings would be beneficial.

2. Related work

While there are many static learning contract templates available in web there is little work done in the similar direction as LeContract.

MEShaT is a web-based tool for monitoring and experience sharing in a project-based learning (Michel and Garrot-Lavoue 2009). Among other features it contains a learning contract tool that is shared between the student, the tutor and the project team. Main focus of MEShaT is in monitoring the individual and group activities in a project based learning. Michel and Garrot-Lavoue do not mention any specific guidance for writing the learning contracts.

There are attempts to standardize learning actions in a formal and uniform way. These attempts have resulted in the Learning Path Specification (Janssen et al. 2008). The aim of Learning Path Specification is to enable the exchange of courses by making the learning actions comparable. Special tools that are based on the Learning Path Specification have been developed in TENCompetence (Herder et al. 2010) and IntelLEO (IntelLEO 2010, 76) projects. However, there is a major difference between describing learning paths and writing learning contracts. In a personal learning contract the learner is expected to describe the learning objectives, resources, strategies and evaluation criteria in his/her own words.

There is no known social software tool that has specific support for writing learning contracts. A social networking site 43 Things enables people to share their goals and hopes. Many people are using this site to share their learning goals and find people with similar interests. Some ideas in 43 Things have influenced the design of LeContract.

3. Design methodology

The design process of LeContract is based on the research-based design methodology (Leinonen et al. 2008). We have used this methodology in several earlier projects (Leinonen et al. 2010; Põldoja and Laanpere 2009) and it has proven to be a flexible and lightweight methodology that supports end-user participation in any stage of design. The research-based design process is divided into four iterative stages, which may happen partly in parallel: (1) contextual inquiry, (2) participatory design, (3) product design, and (4) production of software as hypothesis.

The aim of *contextual inquiry* phase is to define the context and preliminary design challenges. In the case of LeContract the main context is higher education and professional training with self-directed learners. The design challenge is to support the writing and reviewing of learning contracts. In recent years the authors have organized six local and international master level courses where students used blogs to write down learning contracts. In total more than 200 students participated these courses. In the contextual inquiry phase we observed how learning contracts were written and reviewed in these courses. Students found that the main difficulties were related with setting up meaningful learning objectives, strategies and measurable evaluation criteria. It could be argued that having a clear structure and guidelines would scaffold this process. On the other hand teachers perceived the main difficulty being related with following and reviewing the learning contracts in a distributed learning environment. We also interviewed several students to find out how learning contracts supported their learning process and what kind of difficulties they encountered. Based on the interviews we compiled a list of goals that students and teachers have with learning contracts.

As an outcome of contextual inquiry we created four personas that describe goals and motivations of the archetypal users. The creation of personas is a user modeling method where composite user archetypes are created based on the behavioral patterns and motivations of real users. According to Cooper et al. (2007) personas can be divided into six types: primary, secondary, supplemental, customer, served and negative. Our primary persona is a master student Maria who is a self-directed learner (see Figure 1). Secondary personas are mostly satisfied with the primary persona’s interface but have some specific additional needs. In our case these include teacher who has to review the learning contracts and adult learner who is interested in the social networking aspects of LeContract. Fourth persona is a supplemental persona about a teacher with slightly different goals. Each persona includes a short description, goals and a photo. Persona goals were written in the first voice to draw a stronger connection between the design team and the personas.

Age: 26

Education: Master student

Occupation: librarian

Photo by Alessandro Valli,
taken from http://www.flickr.com/photos/liquene/4435467897/

Maria

Maria has studied information science and now she is doing her Master's studies in interactive media. At the same time she has a full time job as a school librarian. Therefore she is interested in combining school assignments with her work as much as possible. At the same time she is a self-directed learner who likes to go in depth in topics that are interesting for her.

Goals:

Personalization: "It is hard to have a full time job and be a master student at the same time. If possible, then I try to choose assignments that can be connected with my work."

Scaffolding: "I feel that often it is difficult to specify all the resources and actions that I have to make in order to achieve my learning objectives. Good examples from other learners help me to refine my contract."

Awareness: "It was good that we had to review our learning contracts. This way I was constantly aware of my objectives and thinking about the strategy to achieve my goals."

Figure 1. Primary persona of LeContract

The second phase of research-based design process is *participatory design*. Participatory design approach emphasizes the importance of involving all the stakeholders from the early phases to design process. Its roots go back to the 1970's when members of workers and trade unions in Scandinavia started to participate in the design and deployment of computer systems at their workplace (Ehn 1992). Participatory design process should be carried out in the context of actual use rather than in design laboratories. LeContract project started quite recently but in the coming autumn term 2010 we have plans to integrate the design process of LeContract in one of the courses where our students will use learning contracts. In participatory design process we are not only designing a concrete piece of software but we have to understand how it fits into a larger system. This system includes networks of learners, their current practices and other tools that they are using for learning purposes.

In order to communicate the design ideas with all the stakeholders we need simple communication tools. One of the methods that is commonly used in the participatory design is scenario-based design. Scenarios are simple stories of people and their activities. Typical scenarios have several characteristic elements. They take place in a certain setting and include actors who have specific goals (Potts 1995). The main purpose of scenarios is to evoke reflection on the design issues. Scenarios can be written from many different perspectives. For example problem scenarios can describe the current situation and encourage discussions about it. Scenarios can be easily revised by end-users who may understand the actual context better than the designers (Carroll 2000).

In this phase we wrote five scenarios that describe typical use cases of LeContract. These scenarios included (1) first experience with LeContract, (2) writing a learning contract, (3) reviewing the learning contracts, (4) creating learning contract templates, and (5) browsing the learning contracts. Previously created personas were used as actors in the scenarios. With each scenario we also wrote a set of questions to start up the discussion. An example scenario with questions is presented in Figure 2.

Maria is a master student who is taking a course on learning theories. In the beginning of the course all the students are asked to write a learning contract. Their teacher is suggesting to use LeContract web site to compose their learning contracts.

Maria goes to LeContract website. She explores the site for a minute and then creates a user account for herself. After logging in she finds quickly how to create a learning contract. LeContract provides learning contract templates in different languages. Maria will choose a template that their teacher suggested to use and will start writing her learning contract. The template has fields for the learning objectives, resources that she will need, strategy to achieve the objectives and evaluation criteria. There are also short help texts that explain what she could write in the learning contract.

When she is done with the learning contract she will add a few keywords that characterize her contract. It is possible to choose from the set of predefined keywords or add her own keywords. In this course she is interested in constructivism, planning to read Piaget and Vygotski.

Finally she is ready to save and publish the learning contract. She will notice that it is also possible to adjust the privacy settings, share the learning contract to social networking sites and get an embed code. When the contract is published she will copy the embed code and add it also to her study blog.

Questions:

- Did this scenario evoke any thoughts?
- Is there something you would like to change in that scenario?
- Could you image yourself to the role of the learner?
- Are there privacy issues related to the learning contracts? Can any learning contract be public?

Figure 2. An example scenario about writing the learning contract

The scenarios were used in participatory design sessions with three teachers and learners who have previous experience with learning contracts. The participants were reading the scenarios and we had a discussion about each scenario. The design sessions were recorded with an audio recorder. A short summary was written about the main outcomes of each design session.

As a result of the participatory design phase we defined the preliminary concepts of LeContract. These concepts are (1) learning contracts, (2) learning contract templates, (3) learners and (4) courses. Relationships between these concepts and key features of LeContract are described in details in the next section.

We are currently in the third phase of research-based design process. The aim of a *product design* phase is to define the use cases and basic interaction with the system. Two main methods that we have used in this phase are user stories and paper prototyping.

User stories are part of an agile software development methodology where they are used to build the bridge between the developers and the end-users. Typical user story describes one feature or requirement in two or three sentences in the everyday language of the user. Cohn (2004) suggests that user stories should be written by end users. In our case the initial set of user stories was written by the designers. Users stories will be negotiated with the end users and additional stories will be written in the upcoming participatory design sessions. From the software development perspective it is important that the user stories are independent, it is possible to estimate the time needed to implement the story, and to test the implementation. User stories are published in the software development environment Trac where stakeholders can discuss and revise the user stories. When the stories are finalized they will be accepted by the main designer.

User stories focus only on the functionality, not on the appearance. Therefore we prepared paper prototypes about these user stories that required a detailed description of the user interface. When making the paper prototypes we followed the practices suggested by Snyder (2003). We divided the required interface into smaller elements so that each screen form, dialog box or a drop down menu was drawn on a separate piece of paper. This way it is easy to rearrange the user interface elements in a different way. Also, a new version of the interface element can be drawn quickly. In a paper prototyping phase it is possible that we find required features that are missing from the initial user stories.

We are planning to organize additional participatory design sessions with paper prototypes. In these sessions we will give open-ended tasks in which the users have to interact with the paper prototype. In case of problems we will also discuss and revise the related user stories.

4. Key concepts of LeContract

We will present the conceptual design of LeContract through explaining the key concepts that we have indicated in the current phase of the design. These concepts and relationships between them are presented in Figure 3.

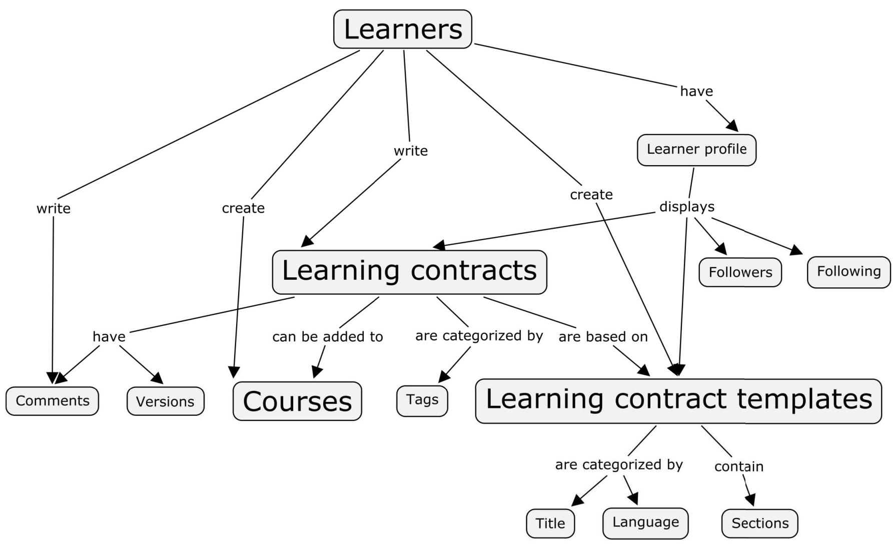


Figure 3. Key concepts of LeContract

4.1 Learners

LeContract is designed according to the principles of social software (Crumlish and Malone 2009), not according to the common design principles of learning technology. Therefore we have decided not to make a technical distinction between the roles of a teacher and a learner. While they have different goals and motivations for using LeContract they will share the same user interface and user rights.

We have currently decided to name this role a *learner*. This was preferred to more technical choices like *member* or *user*. We expect that LeContract will be used in learning settings where the teacher is in the role of a facilitator and fellow learner. In the design sessions it came out that one of the teachers was also writing learning contracts in her courses.

Each learner has a *learner profile* that contains links to all learning contracts and learning contract templates that s/he has created. Social networking is implemented as asymmetric following. This type of connection is suitable when content (learning contracts) are more important than a personal relationship. Learners can start following other people whom they know or who have similar learning objectives. The person will be notified about the new follower but is not required to make a two-way connection. Learner profile will display links to *followers* and to people whom the learner is *following*.

4.2 Learning contracts

Engeström (2005) suggests that successful social networking services are built around ‘social objects’. For example Flickr is built as a photo sharing site and Delicious is built around bookmarks. In case of LeContract the main social objects are *learning contracts*.

Learning contracts in LeContract are based on templates that are scaffolding the writing process with a certain structure and guidelines. Each *section* in the learning contract provides some guiding questions that help the learner to specify his/her learning objectives, strategy or evaluation criteria. The default template that is presented in Table 1 is modified from Anderson et al. (1996) and Harri-Augstein & Webb (1996). The reflection section is not displayed when the learner is writing the initial version of the learning contract. In the tags section the learner is expected to summarize his/her main learning objectives as *tags*, free user-generated keywords. These tags will be used to link learners with similar learning objectives. The table also specifies whether the template field is a single-line text input or multiple-line textarea.

Table 1. Structure of the default learning contract template.

Section	Guiding questions	Field type
Topic	What is the topic I wish to learn about?	text input
Purpose	What is the purpose of my task? Why do I wish to learn about or learn to do a particular task?	textarea
Resources	What kind of technological, material and human resources do I need? How can I get access to these?	textarea
Strategy	How do I intend to go about learning this particular topic/task? What action may be involved and in what order will these be carried out?	textarea
Outcome evaluation	How will I know when I have completed the task/topic successfully? How shall I judge success?	textarea
Reflection	How well did I do? What has worked? What has not worked? Why? What remains to be learnt? What are my strengths and what are	textarea

	my weaknesses? What shall I do next?	
Tags	What do I want to learn? My main learning objectives as tags, separated by commas.	text input

Important part of LeContract is reviewing the learning contracts. Facilitator and fellow learners can *comment* the learning contracts. It is common that the initial learning contracts lack details in several areas. In the design sessions it came out that teachers had difficulties with commenting learning contracts when these were published as blog posts. They would like to have a way to attach comment to a certain section in the learning contract. When the learner has revised the learning contract according to the comments s/he can save a new *version* of the learning contract. Older versions of learning contract will also remain available, so that it is possible to see how the learning contract has evolved over the course. LeContract is designed with an understanding that writing learning contracts is an iterative process.

It is possible to embed the learning contracts to any web site that supports embedding (for example web log, forum, etc.). Embedded version of the learning contract works as a teaser that will invite people to read the complete version of learning contract in LeContract. We expect that the review process will be carried out in LeContract, not in blog post comments.

With learning contracts we also have to think about privacy issues. While we promote the use of open learning environments (Põldoja and Laanpere 2009), we understand that not all learners are ready to share their learning strategies in public. There are sensitive topics that can be better discussed in closed learning environments. In LeContract it should be possible to create private learning contracts and share them only with a person who is going to review the contract.

4.3 Learning contract templates

Learners can also create new *learning contract templates* from scratch or through customizing the existing templates. At first this is important for translating learning contract templates to a different language. Secondly some facilitators may feel that the default template is not suitable for their needs. For example they would like to have guiding questions that are specific for their course. Facilitators can then point learners into certain learning contract template. Also self-directed learners may have a need for their personal template. The number of sections in the template is not fixed but topic and tags are required in every template. All created learning contract templates can be browsed by *language* and *title*.

Learning contract templates created in LeContract will be published under the Creative Commons Attribution license. This way learning contract templates can be considered as open educational resources (Schaffert and Guntram 2008). We reckon that creating a learning contract template is a micro-contribution and attribution requirement is enough to protect the authors. Attribution license is most compatible with other open licenses and makes it possible to reuse the learning contract templates in a wider ecosystem of open educational resources.

4.4 Courses

In the design session it came out that in a formal learning setting teachers would need a possibility to link together all the learning contracts from the same course. For satisfy this requirement we introduced the concept of *courses*. Every learner can create a course in LeContract. Each learning contract can be added to one course.

Having all learning contracts from one course categorized gives us also other benefits. For example it is possible to create a tag cloud that presents all the learning objectives from that course. In an informal learning setting learners can simply ignore the course feature.

5. Conclusions and future work

LeContract can be a considerable support tool for an individual. It provides a framework for structuring learning activities and helps to 'mirror' the learning process to the learner and facilitator. As the needs of learners are articulated into specific purposes, the resources identified and the strategies developed it is a promising mechanism that can provide evidences whether there has been a valued change in one's own ways of thinking and perceiving. On the other hand LeContract is a great source for a facilitator to understand the learner's progress and its dynamics.

This paper described the design work that is still in progress. In the current phase we have indicated the key features that are needed for writing, reviewing and sharing learning contracts on the web. More design work is needed for reviewing the learning contracts and connecting learning objectives with evidences in learners' blog or e-portfolio.

The development process has shown that research-based design methodology provides a flexible framework for designing new tools for learning. Scenario-based design enables to involve the stakeholders to the design process and receive constructive feedback for early design ideas. Personas, scenarios and other artefacts developed in the design process are published in LeContract development site (2010).

6. Acknowledgements

This research was funded by Estonian Science Foundation grant 7663 and Estonian Ministry of Education and Research targeted research grant No. 0130159s08.

7. References

43 Things. http://www.43things.com

Anderson, G., D. Boud, and J. Sampson. 1996. *Learning contracts: a practical guide*. New York: Routledge.

Arenas, E. 2008. Personal learning environments: implications and challenges. In *Lifelong learning: reflecting on successes and framing futures. Keynote and refereed papers from the 5th International Lifelong Learning Conference*, ed. D. Orr, P. A. Danaher, G. Danaher and R.E. Harreveld, 54–59. Rockhampton: Central Queensland University Press.

Attwell, G. 2007. Web2.0, personal learning environments and future of schooling. http://unescochair.blogs.uoc.edu/05102007/web-20-personal-learning-environments-and-the-future-of-schooling/

Carroll, J.M. 2000. *Making Use: Scenario-Based Design of Human-Computer Interactions*. Massachusetts: The MIT Press.

Cohn, M. 2004. *User Stories Applied: For Agile Software Development*. Boston: Addison-Wesley.

Cooper, A., R. Reimann, and D. Cronin. 2007. *About Face 3: The Essentials of Interaction Design*. Indianapolis: Wiley Publishing, Inc.

Crumlish, C. and E. Malone. 2009. *Designing Social Interfaces: Principles, Patterns, and Practices for Improving the User Experience*. Sebastopol: O'Reilly Media, Inc.

Delicious. http://delicious.com

Ehn, P. 1992. Scandinavian design: On participation and skill. In *Usability: Turning Technologies into Tools*, ed. P. Adler and T. Winograd, 96–132. New York: Oxford University Press.

Engeström, J. 2005. Why some social network services work and others don't — Or: the case for object-centered sociality. http://www.zengestrom.com/blog/2005/04/why-some-social-network-services-work-and-others-dont-or-the-case-for-object-centered-sociality.html

Fiedler, S., and K. Pata. 2009. Distributed learning environments and social software: In search for a a framework of design. In *Handbook of Research on Social Software and Developing Community Ontologies*, ed. S. Hatzipanagos and S. Warburton, 145–158. Hershey: IGI Global.

Flickr. http://www.flickr.com

Flock. http://flock.com

Harri-Augstein, S., and I. Webb. 1996. *Learning to Change: A resource for trainers, managers, and learners based on self organised learning.* London: McGraw-Hill.

Herder, E., P. Kärger, A. Berlanga, J. Janssen, and S. Heyenrath. 2010. ID 7.17 – Implementation of the Learning Path Manager and Editor. http://dspace.ou.nl/handle/1820/2269

IntelLEO. 2010. D2.1 IntelLEO Early Prototype Specification.

Janssen, J., H. Hermans, A. Berlanga, and R. Koper. 2008. Learning Path Specification. http://dspace.ou.nl/handle/1820/1620

Johnson, M., and O. Liber. 2008. The personal learning environment and the human condition: from theory to teaching practice. *Interactive Learning Environments* 16, no. 1: 3–15.

Jones, D. 2008. PLEs: framing one future for lifelong learning, e-learning and universities. In *Lifelong Learning: reflecting on successes and framing futures*, ed. D. Orr, P.A. Danaher, G. Danaher, and R.E. Harrevel, 231–236. Rockhampton: Central Queensland University.

Kolas, L., and A. Staupe. 2007. The PLExus Prototype: A PLE realized as Topic Maps. In *Proceedings of the 7th IEEE International Conference on Advanced Learning Technologies (ICALT'07)*, ed. J.M. Spector, D.G. Sampson, T. Okamoto, Kinshuk, S.A. Cerri, M. Ueno and A. Kashihara, 750–752. Washington: IEEE Computer Society Press.

LeContract development site. 2010. http://www.lecontract.org

Leinonen, T., T. Toikkanen, and K. Silfvast. 2008. Software as Hypothesis: Research-Based Design Methodology. In *Proceedings of Participatory Design Conference 2008, Indiana University, Oct 1–4 2008.*

Leinonen, T., J. Purma, H. Põldoja, and T. Toikkanen. 2010. Information Architecture and Design Solutions Scaffolding Authoring of Open Educational

Resources. *IEEE Transactions on Learning Technologies*, preprint. http://doi.ieeecomputersociety.org/10.1109/TLT.2010.2

Michel, C., and E. Garrot-Lavoue. 2009. MEShaT: Monitoring and experience sharing tool for project-based learning. In *Cognition and Exploratory Learning in Digital Ages (CELDA 2009), Rome, Italy, 20-22 November 2009*, 69–76.

Netvibes. http://www.netvibes.com

Potts, C. 1995. Using schematic scenarios to understand user needs. In *Proceedings of the 1st conference on Designing interactive systems: processes, practices, methods, & techniques*, ed. G.M. Olson and S. Schuon, 247–256. New York: ACM.

Põldoja, H., and M. Laanpere. 2009. Conceptual Design of EduFeedr — an Educationally Enhanced Mash-up Tool for Agora Courses. In *Mashup Personal Learning Environments 2009. Proceedings of the 2nd International Workshop on Mashup Personal Learning Environments (MUPPLE09), Nice, France, September 29, 2009*, ed. F. Wild, M. Kalz, M. Palmér and D. Müller. Aachen: CEUR-WS.

Schaffert, S. and G. Guntram. 2008. Open Educational Resources and Practices. *eLearning Papers*, no. 7.

Snyder, C. 2003. *Paper Prototyping: The Fast and Easy Way to Design and Refine User Interfaces*. San Francisco: Morgan Kaufmann.

van Harmelen, M. 2006. Personal Learning environments. In *Proceedings of the 6th IEEE International Conference on Advanced Learning Technologies (ICALT'06)*, ed. Kinshuk, R. Koper, P. Kommers, P. Kirschner, D. Sampson, and W. Didderen, 815–816. Washington: IEEE Computer Society Press.

Väljataga, T., and M. Laanpere. Forthcoming. Learner control and personal learning environments: a challenge for instructional design. *Journal of Interactive Learning Environments*.

Wilson, S., O. Liber, P. Beauvoir, C. Milligan, M. Johnson, and P. Sharples. 2006. Personal learning environments: Challenging the dominant design of educational systems. *Journal of e-Learning and Knowledge Society* 3, no. 2: 27–38.

Publication 5

Põldoja, H., Väljataga, T., Laanpere, M., & Tammets, K. (2014). Web-based self- and peer-assessment of teachers' digital competencies. *World Wide Web, 17*(2), 255–269. http://doi.org/10.1007/s11280-012-0176-2

World Wide Web (2014) 17:255–269
DOI 10.1007/s11280-012-0176-2

Web-based self- and peer-assessment of teachers' digital competencies

Hans Põldoja · Terje Väljataga · Mart Laanpere · Kairit Tammets

Received: 1 March 2012 / Revised: 15 May 2012
Accepted: 12 June 2012 / Published online: 11 July 2012

Abstract Although there exist several alternative frameworks and standards for describing the digital competencies expected from teachers, there is a lack of Web-based assessment tools that allow authentic, reliable and valid assessment of these competencies. This paper addresses the design challenges related to a software solution for self- and peer-assessment of teachers' digital competencies. The empirical part of the paper describes the participatory design process and results from the first user testing of a Web-based self- and peer-assessment tool DigiMina, which supports teachers in building and sharing a personal competency profile. In DigiMina, the competencies are assessed by a teacher herself or by her peers using the performance indicators that are based on the competency model NETS for Teachers created by the International Society of Technology in Education.

Keywords educational technology · digital competencies · self-assessment · peer-assessment · conceptual design

1 Introduction

The use of Internet has grown rapidly both in quantity and in quality: while the number of Internet users worldwide increased from 0.36 (in 2000) to 2.26 billions (end of 2011), also the way people make use of WWW has changed significantly.

H. Põldoja (✉) · T. Väljataga · M. Laanpere · K. Tammets
Institute of Informatics, Tallinn University, Narva mnt 25, Tallinn 10120, Estonia
e-mail: Hans.Poldoja@tlu.ee

T. Väljataga
e-mail: Terje.Valjataga@tlu.ee

M. Laanpere
e-mail: Mart.Laanpere@tlu.ee

K. Tammets
e-mail: Kairit.Tammets@tlu.ee

Instead of passive reading and downloading, WWW is increasingly used for distributed and collaborative learning [21]. We are entering the digital age, where majority of artifacts created by us at the workplace and at home are digital and accessible over Internet. Desktop computers are not anymore the dominant hardware devices for accessing the Internet as our mobile phones, TV sets, office and home appliances turn digital and get online. Schools have to cope with the situation where children are in many ways more competent in handling these new digital tools than teachers. In order to avoid alienation from society, technology-related teacher training needs upgrading: focus should change from "how to use MS Word" towards "how can I improve my work and my students' learning with this new digital technology". This paper addresses the recent changes in defining the content and format for teachers' digital competency standards and proposes an innovative Web-based tool and method for online assessment of these competencies.

We argue that generic ICT competency frameworks such as International Computer Driving Licence (ICDL) [9] provide too narrow and de-contextualized perspective on the use of ICT in teachers' work. Therefore several international initiatives are aiming at developing more relevant digital competency frameworks for teachers. These competency frameworks are outlined in the following section of this paper. In this study we define competency in line with [26], as an integrated set of personal characteristics (e.g. skills, knowledge, attitudes, social capital, experiences) that an individual possesses or needs to develop in order to perform an activity within a specific work-related context. Teachers' digital competencies are here used as a synonym for educational technology competencies: these are the competencies that are expected from teachers in digital age, in order to facilitate efficient and creative learning of their students, but also to coordinate their own sustainable professional development in the context where the pace of technological innovation is only increasing.

Our research is carried out in the contexts of pre-service and in-service teacher education in Estonia. The national Educational Technology Competency Model (ETCM) [27] for teachers is presented in section 3.1. While many teachers have participated the professional development courses on using educational technology, there is a low awareness of educational technology competencies. In order to plan teachers' professional development and training needs it is necessary to measure their level of educational technology competencies. One option to assess the educational technology competencies is to use a Web-based assessment tool. However, ETCM contains also complex performance indicators that cannot be assessed using simple automated tests. Other assessment methods such as self- or peer assessment are needed to assess these competencies. This paper addresses the following research problem: to what extent and how could be teachers' educational technology competencies assessed using a Web-based tool?

Together with the assessment method we are designing and developing a Web-based assessment tool named DigiMina (*DigitalMe* in Estonian). In section 3 we discuss the main design challenges for assessing teachers' educational technology competencies. The following sections describe the participatory design research methodology that is used in this study, the conceptual design of DigiMina tool and the current software implementation of DigiMina tool. The final section will summarize the results from the first field trial of DigiMina involving 50 teachers.

This article is a revised version of a paper presented at the 10th International Conference on Web-based Learning (ICWL 2011) [25]. It has been extended by a description of the software implementation and a validation study.

2 Teachers' digital competencies

There are several initiatives and approaches aiming at developing standards, which can be a basis for measuring teachers' educational technology competencies. In this section we will shortly discuss three of them.

Hinostroza et al. [13] claim that there are at least two approaches to defining ICT-related competences: the traditional one aims at defining skills oriented towards mastering the hardware and software [2, 24], while the alternative approach is describing wider competencies that can be developed while using software as means [1]. The latter competences refer for instance to distance collaboration and communication; creation, sharing and mastering knowledge through filtering information; allocation of materials, creation of communities etc. [14, 3]. For instance Goodyear et al. [11] looked at digital competencies associated with the roles of teachers while facilitating online courses with different hardware and software.

One of the most widespread digital competency standards, the International Computer Driving License (ICDL) started as a European initiative but has currently expanded to 148 countries. ICDL certifies that the holder has knowledge of basic concepts of Information Technology (IT), technically it should be accepted in any field or occupation. Modules like concept of ICT, using personal computer and managing files, word processing, spreadsheets, databases, presentations and communication have to be completed in order to achieve the basic level of digital literacy [9]. Testing takes place in certified exam centers and contains both multiple-choice tests and tasks performed with the help of computers in the lab.

European Schoolnet [10] conducted the survey by analyzing the policies of European Teachers' ICT competencies and points out that although ICDL is commonly agreed certification, it is too much focused on generic ICT skills. Because of this, ICDL framework is neglecting dimensions, which are pedagogically significant [3] and is leaving out important contextual information. In addition, ICDL was criticized for poor support for tracking of informal learning that happens outside the school environment.

UNESCO ICT Competency Framework for Teachers (ICT-CFT) aims at improving teachers' practice using ICT in professional activities by providing a set of guidelines for creating national-level competency models. The framework addresses six sub-domains of the teachers' work: policy and vision, curriculum and assessment, pedagogy, ICT, organization and administration, and teacher professional development [29].

National Educational Technology Standards for Teachers (NETS-T) is a competency model developed in 2008 by the International Society for Technology in Education (ISTE) [18]. ISTE NETS-T aims to make teachers as role models for students with regard to digital-age knowledge work skills. The main advantage of ISTE NETS-T is support for standard-based performance assessment in the similar way for teachers, school administrators and students. ISTE NETS-T acknowledges the importance of developing and assessing competencies in the authentic context of teachers' work.

Each of the discussed competency frameworks has its benefits in specific context. ICDL provides globally acknowledged and easy-to-implement generic ICT skill tests for professionals in various fields, whereas UNESCO and ISTE have more contextualized, competency- and performance-based approach.

Estonian policy-makers have chosen ISTE NETS-T as the most suitable framework for developing the national educational technology competency model for teachers (ETCM). This competency model was recently finalized by a group of experts (including two co-authors of this paper) and it serves as the basis for developing competency tests also for DigiMina project. The model aims at in-service teachers' competency development in primary, secondary, vocational and higher education level. The model consists of five core competencies:

1. Facilitate and inspire student learning and creativity
2. Design and develop digital-age learning experiences and assessments
3. Model digital age work and learning
4. Promote and model digital-age citizenship and responsibility
5. Engaging in professional growth and leadership

Each of these competencies includes 4 detailed sub-competencies, which are defined in performance-based and contextualized manner.

3 Design challenges

In the following section we will analyze the main design challenges for Web-based assessment of teachers' digital competencies. The analysis is addressing these challenges in relation of two different perspectives: (1) how to select appropriate methods and instruments for assessing digital competencies, and (2) how to implement selected assessment methods in a Web-based tool.

3.1 Measuring digital competencies

Measuring digital competencies is a challenging task, which is seen in several attempts to develop frameworks and models. According to Calvani et al. [3] there are no adequate instruments to assess and promote educational technology competencies. Cumming and Maxwell [7] put emphasis on two major theoretical considerations. The first relates to conceptions of validity, with emphasis on the appropriateness of assessment tasks as indicators of standards, and on the appropriateness of interpretation of assessment outcomes as indicators of learning [7]. Assessment methodology and instruments must be reliable, valid, flexible, but also affordable with respect to time and costs. Methodology together with assessment instrument must ensure that assessment decisions involve the evaluation of sufficient evidence to judge the level of competency of the teacher.

Reliability in our context is understood as a measure of the reproducibility, consistency and accuracy of an assessing methodology [30]. The methodology must demonstrate similar outcomes for teachers with equal competency at different times or places, regardless of the assessor conducting the assessment.

Validity, on the other hand, focuses on whether an assessment methodology and its instrument actually succeeds in evaluating the competencies that it is designed to evaluate [30]. Validity refers to the extent to which the interpretation and use of an assessment outcome can be supported by evidence. In order to assess whether a teacher is competent, they are judged against competency standards or competency benchmarks developed by a group of experts. A competency standard is comprised of individual units of competency that include the essential information needed to assess a teacher. However, there is a question what sort of evidence needs to be collected in order to assess and make judgments on which benchmark a teacher meets.

For instance, for measuring clinical competencies, Miller [23] has developed a pyramid of competencies, which is a simple conceptual model outlining the issues involved when analyzing validity. The pyramid consists of four levels:

1. knows—basic facts

2. knows how—applied knowledge
3. shows how—performance assessment in vitro
4. does—performance assessment in vivo

Such a conceptual model has also a potential in the context of teacher education and their educational technology competencies. Taking the model as a basis and looking at the ways of how educational technology competencies have been assessed, the literature overview shows that the majority of assessment models and tests focus on the first basic level—assessing a pure technological knowledge and skills with basic computer-based multiple choice tests. Developing such tests is rather time consuming, but they guarantee high reliability because of the large number of items that can be easily tested and marked [30]. The main drawback of these tests is seen in their de-contextualization, lack of authenticity in tasks and assessment of the most trivial parts of knowledge.

For assessing educational technology competency advancement such an approach has some limitations and has led to an increasing focus on more sophisticated assessment methods such as testing "knows how"—i.e., the assessment of knowledge as applied to problem solving or educational technology reasoning and decision-making in specific contexts. Thus, the test items must be problem-based and situated in authentic context.

Level 3, "shows how" in Miller's pyramid, can be assessed by practical examinations, observed long or short cases. The only way to assess level 4, "does", is to observe the person at work in the real world. As the levels 3 and 4 are difficult to perform in an online environment, our focus is on level 2: "knows how". Difficulties in setting up "knows how" tests involve combining the application of knowledge with the large range of problems [30]. "Equally, reference to the context in which competencies are acquired is important, as is reference to the context in which they will subsequently be applied" (p.9) [8]. Digital competencies cannot be separated from the practical contexts in which they are acquired and applied.

We identified 5 levels of performance for each competency in ETCM and created an assessment rubric, which provides a "knows how" performance criteria [8] for each level. The main difference in comparison to the previous competency models is the emphasis of our assessment rubric on facilitating and supporting learners to use technology for developing their creativity, personal learning environment, learning habits and skills, but also in contextualizing the performance indicators in real-life situations a digital-age teachers are facing today in Estonia.

We also created a set of problem-based cases anchored in authentic settings of teachers' work and related self-test questions that allow automatic feedback from the DigiMina tool.

The second design challenge for DigiMina project is to define methodologically sound self- and peer assessment test items for each performance indicator, allowing to measure each competency in valid and reliable manner.

3.2 Web-based assessment of competencies

As authentic context for performance is one of main defining aspects of competency [26], authentic assessment methods seem to be the most suitable for measuring the level of competency. Quite often, authentic assessment methods are contrasted with standardized testing and other forms of computer-assisted assessment [22]. Yet, the authenticity of the assessment could be implemented in various ways, without a need to avoid computer-assisted assessment tools. Gulikers et al. [12] have suggested a five-dimensional framework for authentic assessment, defining five different aspects of enhancing the authenticity of assessment:

- tasks: meaningful, relevant, typical, complex, ownership of problem and solution space;
- physical context: similar to professional work space and time frame, professional tools;
- social context: similar to social context of professional practice (incl. decision making);
- form: demonstration and presentation of professionally relevant results, multiple indicators;
- criteria: used in professional practice, related to realistic process/product, explicit.

Using the DigiMina software as hypothesis, we demonstrate that authenticity could be built in the Web-based assessment tool by addressing all five dimensions of Guliker's framework.

The third challenge of DigiMina project is to combine the requirements for authentic assessment of competencies with the limited possibilities of an online testing tool.

4 Methodology

The design process follows the research-based design methodology [20]. In this methodology the design process is divided into four iterative stages, which may take place partly in parallel: (1) contextual inquiry, (2) participatory design, (3) product design, and (4) production of software as hypothesis.

The main aim of contextual inquiry phase is to define the context and the design challenges. In case of DigiMina the main context is teacher education with special focus on novice teachers who are doing their induction year in schools. The design challenge is to enable teachers to evaluate their educational technology competencies. In this phase we used personas [6] as a method to describe the goals and motivations of archetypal users. We developed five personas that cover our expected user groups: (1) teacher training master student, (2) novice teacher, (3) experienced teacher, (4) educational technologist of a school and (5) trainings manager. These personas served as a basis for writing the scenarios.

The second phase of research-based design process is participatory design, involving potential users of the system in design sessions. In order to communicate the design ideas with our stakeholders we need simple and non-technical communication tools. One such communication method is scenario-based design [4] where typical use cases are described as simple stories of people and their activities. These stories can be used in a participatory design session to evoke ideas and discussion. We prepared four main scenarios that addressed directly the above mentioned design challenges: (1) master student is evaluating her educational technology competencies, (2) peer assessment of problem solving tasks, (3) educational technologist of a school is getting an overview of teachers' educational technology competencies and (4) training manager is compiling a training group with sufficient level of competencies.

The scenarios were evaluated in two participatory design sessions. The first session included 3 novice teachers. The second session included an expert teacher and a teacher trainer. The first design session focused on the first two scenarios, the second design session included all four scenarios. While the participants found the scenarios realistic they pointed out several details that could be changed in the scenarios. The design sessions indicated need for two additional personas: facilitator of master students and novice teachers, and a teacher trainer. As an outcome of the participatory design phase we have defined the main concepts of DigiMina. These are discussed in the next section.

The third phase of research-based design process, which was product design, resulted with use cases and basic interaction. This was done through agile user stories [5] and prototyping.

User stories were mapped to the information architecture diagram. We have developed a set of paper prototypes and high-fidelity prototypes about main pages of the system. Currently we have completed the final stage: production of the software as hypothesis. Functionalities and other characteristics of DigiMina software are described in section 6.

5 Conceptual design of DigiMina

The conceptual design of DigiMina is presented as a concept map (see Figure 1). Key concepts are emphasized in bold and explained in details in the following section. This conceptual map covers both the user interface vocabulary and concepts related to educational technology competencies.

5.1 Competency test

The central feature of the system is a competency test that is taken by the users. One of the usability issues with competency test is a large number of tasks. There are 20 competencies in 5 groups. Each competency is assessed on 5-point scale. We have taken several steps to solve this issue. Before starting the competency test users can pre-evaluate their competency level in 5 competency groups. When taking the test they will receive tasks at the specified competency level. Also it is possible to save the test and continue answering later.

Competency test can be taken several times to measure the advancement in educational technology competencies. In a typical scenario the first competency test is taken during

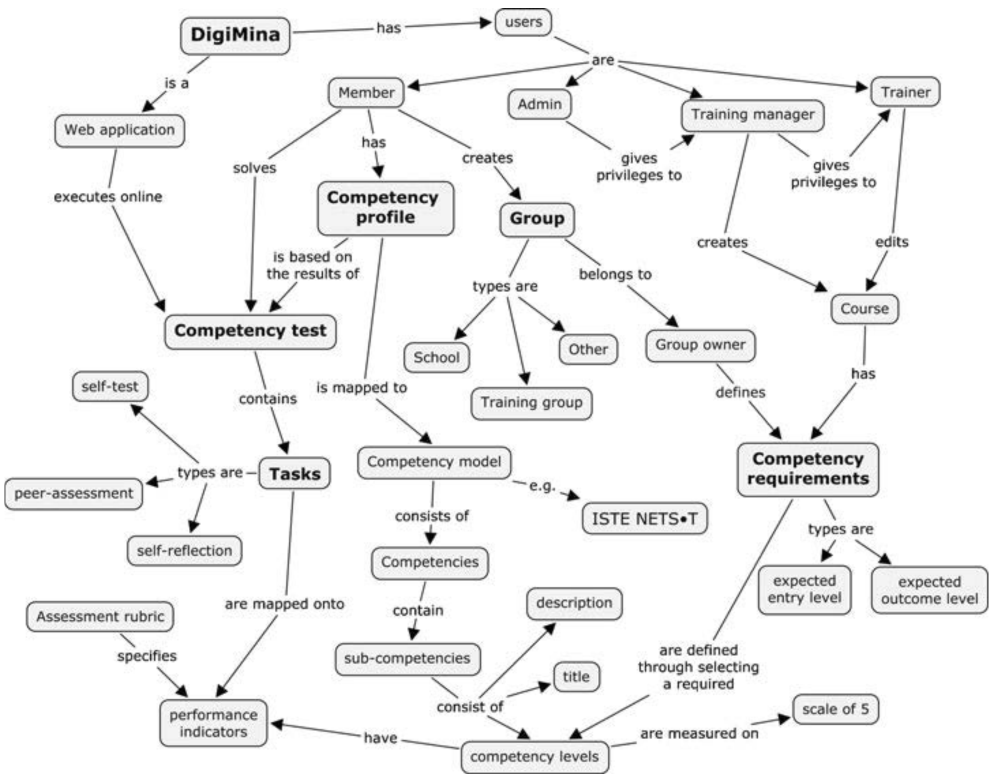


Figure 1 Key concepts of DigiMina.

educational technology course in the university, second test in the induction year in a school and additional tests when working as a teacher. All the results can be compared with the earlier results.

5.2 Tasks

Competency test contains tasks that are mapped to performance indicators. These performance indicators are specified with the assessment rubric. The tasks are divided into three types according to the assessment method: (1) automatically assessed self-test items, (2) peer-assessment tasks and (3) self-reflection tasks. Whenever possible, we tried to compose a self-test item for each competency (succeeded in 29 cases), but often it would have compromised the authenticity of the tasks, so we had to create either peer-assessment (23 cases) or self-reflection task (41 cases) instead. An example of a self-test task could be a multiple-response item based on a screencast that shows how a teacher is publishing a learning object into a repository, while making several small mistakes in the process. An example of a peer-assessment task expects the teacher to adapt a given study guide to her own working context (age range, subject area, software). Adapted study guide will be submitted to qualitative peer-assessment procedure by another teacher. An example of a self-reflection task expects the teacher to reflect on the process and results of her experience of creating digital learning resources based on one real-life example.

Peer-assessed tasks are typically used in higher competency levels where the user has to write a solution to authentic problem. In that case the answer has to be evaluated by another DigiMina user with the same or higher competency level. In case of teacher students and novice teachers this can be one of their group members.

The scope of DigiMina is limited to delivery of competency tests and tasks. Tasks are created in a specialized question and test authoring tool TATS and stored in a format compatible with IMS Question & Test Interoperability Specification [28].

5.3 Competency profile

When the user has completed all the tasks the system will display her competency profile. This includes a diagram that displays her competency level in all 20 competencies. In the competency profile it is possible to compare your competency levels with the average competency level of various groups (other novice teachers, other teachers in your school, other teachers in your subject, all DigiMina users, etc.). It is possible to make the competency profile public or share it with selected people.

5.4 Group

In order to connect teacher students from the same course or teachers from the same school it is possible to create groups. The creator of the group (typically facilitator of the course or educational technologist of the school) is able to see the competency profiles of other group members and various statistics about the competencies. In a school setting DigiMina can be used to find out teachers' training needs in educational technology.

5.5 Competency requirements

When DigiMina will contain competency profiles of a large number of teachers, it will become a valuable tool for planning teacher trainings and organizing training groups. Educational technology related teacher trainings can be described with competency requirements that specify expected entry level and expected outcome level in certain competencies.

Teacher trainers will be able to see the competency profiles of teachers who apply for the trainings. In a school level the group owner can define specific competency requirements.

6 Software implementation

DigiMina software is implemented as a plugin for an open-source community platform Elgg[1], in order to allow its seamless integration with the national educational portal Koolielu.ee. Koolielu.ee is also built on top of Elgg and more than 25% of primary and secondary school teachers in Estonia are already registered as users of this portal. As the Koolielu.ee portal contains also professional development course offerings for teachers, these can be later mapped to DigiMina competency model, which turns DigiMina into a course recommender system. Yet, DigiMina can also be used as a stand-alone server software.

A competency model is imported into DigiMina as an XML file. Although we ended up in using a self-defined structure for this XML file, we used HR-XML [15] and XML binding for IMS RDCEO [17] as guiding examples. The descriptors for competencies in this XML format were derived from IntelLEO competency ontology [19]. A partial XML structure which contains one sub-competency together with assessment criteria on level 1 is presented in the following example.

```
<?xml version="1.0" encoding="UTF-8"?>
<competency-model>
  <title xml:lang="en">Teachers' EdTech Competency Model</title>
  <competency>
    <title xml:lang="en">Model Digital-Age Work & Learning</title>
    <sub-competency>
      <title xml:lang="en">Demonstrate fluency in technology
systems and the transfer of current knowledge to new technologies
and situations</title>
      <performance-level>
        <level>1</level>
        <description xml:lang="en">Creates a user account in a
web-based system and creates/uploads resources.</description>
      </performance-level>
</sub-competency>
  </competency>
</competency-model>
```

DigiMina software supports currently importing only three question types (choiceInteraction with single and multiple response and extendedTextInteraction for peer-assessment tasks) out of 17 types described in IMS QTI specification 2.1 [16]. Most of the items include embedded video or screenshots, in order to create authentic context for a task at hand. In the future, we are planning to implement support for additional IMS QTI item types, e.g. ordering the lists (orderInteraction) and associating the pairs (associateInteraction).

[1] http://elgg.org/

In the current version of DigiMina software the following functionalities have been implemented:

Creating the DigiMina user profile for oneself User fills in a Web form with his/her personal data, specifying the access restrictions for each field (options: anyone, logged-in DigiMina users, only my groups, private).

Self-estimation of one's competences User selects a competency from the competency model, reads 5 performance descriptions from assessment rubric for the selected competency and indicates her/his competency level according to her/his self-estimation (there are 5 competency levels for each competency).

Self-test User is directed to a test item on the level she estimated; user responds to a test item and in case of correct response, a test item for the next level is displayed. This procedure is repeated until either (1) incorrect response occurs, (2) the fifth level is reached or (3) there are no self-test items for the next level (as explained above, most of the competencies on the level 4 and 5 cannot be tested with multiple choice items). The aim of DigiMina is to support teachers' self-assessment, therefore we have not implemented any technical restrictions that are common to examination tools (limited answering time, etc.). An example self-test item is presented on Figure 2.

Fallback In case of incorrect response to a self-test item, the user is provided a new test item from the lower competency level. This is repeated until either (1) the correct response occurs or (2) the user fails on the lowest (first) competency level.

Random selection of items In case there are several self-test items for one competency level, DigiMina selects randomly one of these.

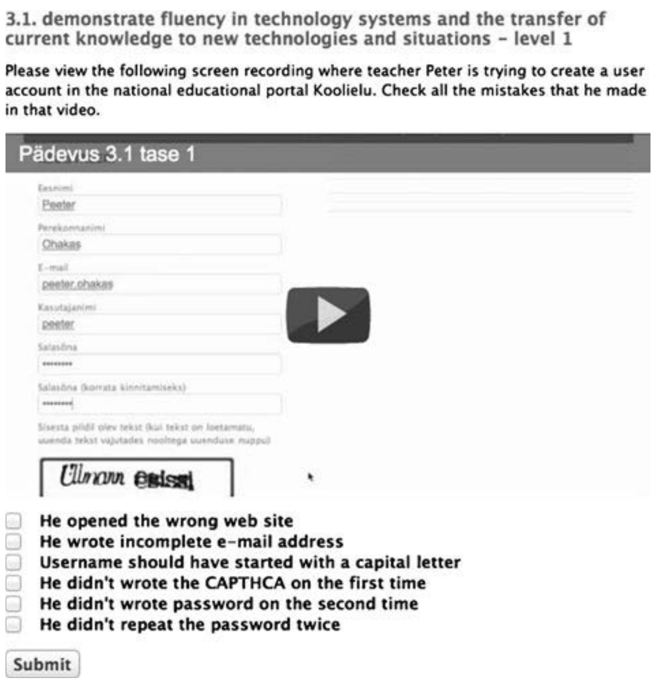


Figure 2 Self-test item with embedded video and multiple response question.

Peer-reviewed tasks In case there are no self-test items for selected competency level, DigiMina provides a task which cannot be automatically evaluated. User will submit her/his response to this assignment in the form of text, hyperlink to her blog post or uploaded file. DigiMina assigns a reviewer for this task, selecting from users who have already successfully validated their competency on this level. The reviewer receives invitation via e-mail, gives feedback to submitted response and decides whether the submission has passed or failed.

Displaying a competency profile After completing competency assessment for at least one competency sub-domain (there are 5 sub-domains in the DigiMina competency model for teachers), user can view and share her/his competency profile (see Figure 3).

DigiMina also provides a compact competency profile that teachers can embed to their blog or other online profile. Compact competency profile displays an average competency level for all five competency sub-domains and has a link to the complete competency profile in DigiMina. This way teachers can connect DigiMina to the ecosystem of online tools that they use for teaching and professional development.

DigiMina is an open-source software, released under Apache 2.0 license. The documentation, design artifacts and source code are available at http://trac.htk.tlu.ee/digimina. In order to involve stakeholders in the participatory design process we decided to keep majority of the design artifacts in Estonian. However, the user interface is originally implemented in English language and is later localized to Estonian.

7 Validation study

A small-scale experiment was conducted in order to validate both DigiMina software, a set of self-test questions and related approach to online self- and peer-assessment of teachers' digital competences. A group of 50 teachers, all from different primary and secondary schools across Estonia, were invited to go through the complete workflow of self- and

Figure 3 Competency profile.

peer-assessment of their digital competencies using DigiMina tool. As the process of assessing full range of competencies listed in the national digital competency model for teachers would take too much time, it was decided to include only one competency sub-domain in the assessment exercise: modeling digital-age work and learning. A complete set of test questions (1–2 items per competency) were authored in TATS environment and imported into DigiMina in QTI XML format, where they were bound to the relevant competency definitions in teachers' digital competency model.

After these preparations were completed, a group of 50 teachers created DigiMina user accounts for themselves, filled in the DigiMina user profile and initiated a competency test, consisting of five phases: (1) estimating one's performance level for each of the 4 competencies in selected competency sub-domain (modeling digital-age work environment), (2) responding to self-test questions for estimated performance level, (3) if needed, responding to open-ended questions (only when competency levels 4 or 5 were estimated), (4) performing a peer-assessment (only if requested), and (5) sharing one's competency profile with other teachers (optional task).

Together with initial demonstration of the DigiMina tool, the phases 1 and 2 took about 30 min to complete by all teachers in the lab settings, while the phases 3–5 were completed within the next 2 weeks. All participants were asked to fill in the survey questionnaire after completing the testing of DigiMina. Only 35 responses were received to the anonymous online questionnaire, which was implemented using LimeSurvey software. Only one of these 35 respondents was male (although there were 4 male teachers among testers), the average age of respondents was 39. Figure 4 below shows the distribution of respondents with regard to curriculum subjects they teach in school.

The first block of the questionnaire addressed the usability and perceived usefulness of DigiMina software. Respondents were asked to give feedback on ease of use of the system in relation to every basic operation in the workflow, responses were given on the scale of 5 (see Figure 5 below). The easiest operations for users were creating a user account and launching a competency test, while the most complicated operations appeared to be the ones related with launching and completing the peer-assessment, along with regulating access to one's personal competency profile. Almost 40% of users did not have to go through the two-phase nature of peer-assessment procedure, as they did not reach the competency levels 4 or 5 where open-ended questions were given. Regulating access to one's competency profile was an optional task, this is why half of the respondents chose not to do it.

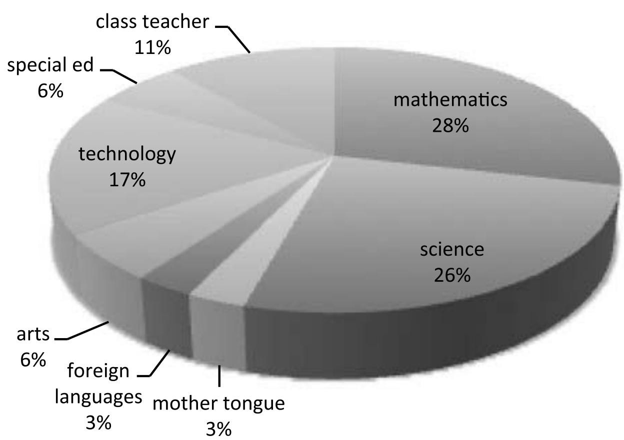


Figure 4 Distribution of respondents by the subjects they teach.

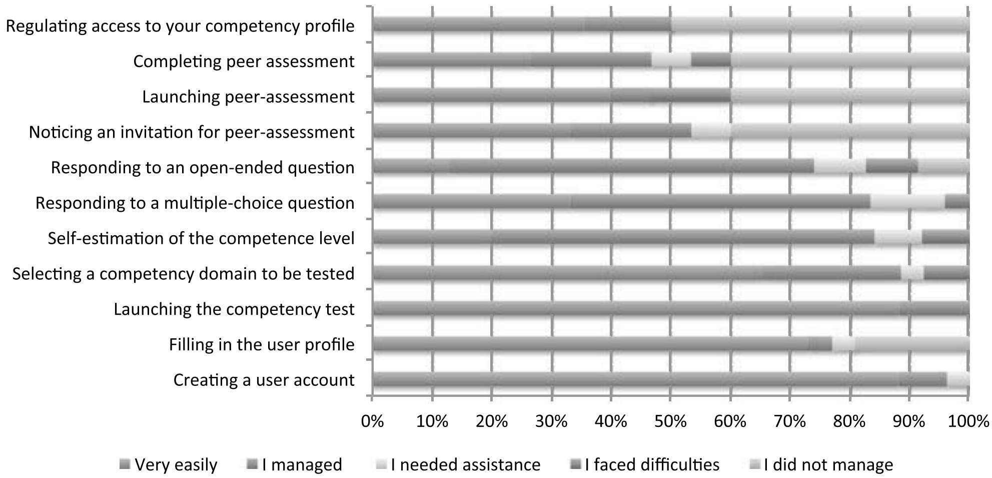


Figure 5 Perceived ease of use of DigiMina software.

Half of the respondents considered the system to be easy to use, only one person disagreed strongly with such claim. With regard to the user interface of DigiMina, 75% found it to be intuitive and easy to navigate. When asked, who would benefit from DigiMina tool, the majority (over 90%) of respondents saw that teacher trainers and educational technologists in schools would benefit significantly more than teachers themselves or researchers. More than 70% of respondents believed that teachers would not use such tool on their own initiative, without request or forcing. This can be explained by the ongoing heated discussion in media on teachers' workload and calls to reduce bureaucracy in Estonian schools. Respondents were also quite skeptical about feasibility of DigiMina's peer-assessment process, based on random assignment of peer-reviewers who are expected to contribute on quid pro quo basis. Even during our experiment, almost half of the participants did not respond to peer-assessment request sent to them via e-mail message. This led us to considering adding a reputation mechanism to DigiMina, allowing users to gain reputation in the form of badges when contributing to peer-assessment. There is also a need to ask permission of every user upon creation of DigiMina user account, on which conditions (period, frequency) would she agree to act as a peer-reviewer.

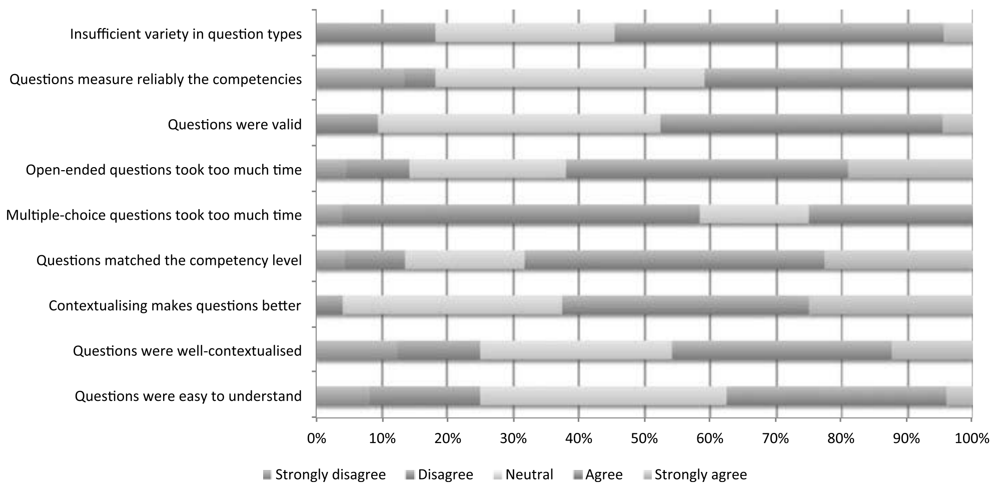


Figure 6 Feedback to DigiMina self-test questions.

Figure 6 below illustrates the distribution of responses to questions related to DigiMina test questions. Respondents were generally satisfied with reliability and validity of questions, even more with the way the questions were contextualized within teachers' everyday work. While the multiple-choice items did not take too much time to respond to, the perceived effort was significantly higher for open-ended questions submitted to peer-review.

In general, teachers who took part in the DigiMina validation experiment, were satisfied with both: our approach to Web-based self- and peer assessment of teachers' digital competencies and how it was implemented in the design of the DigiMina tool. In the free-form feedback several respondents encouraged us to finalize the DigiMina tool and to integrate it into the main national educational portal Koolielu, where it could receive more attention and use.

8 Conclusions and future work

Digital competency frameworks play an important role in systematic support of teachers' professional development. This paper analyzed the design for Web-based assessment of teachers' digital competencies and presented the conceptual design of a Web-based competency assessment tool called DigiMina. Initial results from a validation study that involved fifty teachers were presented and discussed.

DigiMina is designed not as a monolithic Web application, but as one component in a larger digital ecosystem of distributed tools that teachers are using in their everyday work in the digital age. For instance, the test items are not developed inside DigiMina, but are imported from test item authoring tool TATS or Learning Object Repositories. Teachers' competency profiles created with DigiMina can be linked and embedded to other social media systems and integrated into national teachers' portal (e.g. for providing more relevant recommendations on professional development courses).

The next iteration of our research-based design focuses on integrating the DigiMina tool with the larger digital ecosystem (educational portal Koolielu, teachers' e-portfolios, teachers' qualification registry in the Ministry of Education and Research, various e-learning environments). In addition to supporting teachers' professional development DigiMina will be used for collecting valuable data for further research on teachers' professional development. We foresee that DigiMina software can be also used as a generic competency assessment tool. This requires describing a competency model in XML format, preparing assessment tasks and importing these to DigiMina.

Acknowledgments This research was funded by Estonian Ministry of Education and Research targeted research grant No. 0130159s08.

References

1. Anderson, R.E.: Stellar Cases of Technology-Supported Innovations. In: Kozma, R.B. (ed.) Technology, Innovation, and Educational Change: A Global Perspective, pp. 195–215. ISTE, Eugene (2003)
2. Bawden, D.: Information and digital literacies: a review of concepts. J. Doc. **57**(2), 218–259 (2001)
3. Calvani, A., Cartelli, A., Fini, A., Ranieri, M.: Models and instruments for assessing digital competence at school. J. e Learn. Knowl. Soc. **4**, 183–193 (2008)
4. Carroll, J.M.: Making Use: Scenario-Based Design of Human-Computer Interactions. The MIT Press, Cambridge (2000)

5. Cohn, M.: User Stories Applied: For Agile Software Development. Addison-Wesley, Boston (2004)
6. Cooper, A., Reimann, R., Cronin, D.: About Face 3: The Essentials of Interaction Design. Wiley Publishing, Inc., Indianapolis (2007)
7. Cumming, J.J., Maxwell, G.: Contextualising authentic assessment. Assess. Educ. Princ. Pol. Pract. **6**, 177–194 (1999)
8. de Pablos Pons, J.: Repositori institucional: higher education and the knowledge society. information and digital competencies. RUSC. Revista de Universidad y Sociedad del Conocimiento **7**, 6–15 (2010)
9. ECDL Foundation: http://www.ecdl.org/ (2012). Accessed 29 February 2012
10. European Schoolnet: Assessment Schemes for Teachers' ICT competence. http://www-old.eun.org/insight-pdf/special_reports/PIC_Report_Assessment%20schemes_insightn.pdf (2005). Accessed 29 February 2012
11. Goodyear, P., Salmon, G., Spector, J.M., Steeples, C., Tickner, S.: Competences for online teaching: a special report. Educ. Technol. Res. Dev. **49**(1), 65–72 (2001)
12. Gulikers, J.T.M., Bastiaens, T.J., Kirschner, P.A.: A five-dimensional framework for authentic assessment. Educ. Technol. Res. Dev. **52**, 67–86 (2004)
13. Hinostroza, J.E., Labbé, C., López, L., Iost, H.: Traditional and Emerging IT Applications for Learning. In: Voogt, J., Knezek, G. (eds.) International Handbook of Information Technology in Primary and Secondary Education, vol. 20, pp. 81–96. Springer, New York (2008)
14. Hogenbirk, P., de Rijcke, F. (eds.): Teachers: It clicks Professional development for good ICT practice. The Inspectorate of Education, Utrecht (2006)
15. HR-XML Consortium: HR-XML 3.2 Standards Release. http://ns.hr-xml.org/schemas/org_hr-xml/3_2/Documentation/indexes/index.php (2011). Accessed 29 February 2012
16. IMSGLC: IMS Question and Test Interoperability Implementation Guide. http://www.imsglobal.org/question/qtiv2p1pd2/imsqti_implv2p1pd2.html (2006). Accessed 29 February 2012
17. IMSGLC: IMS Reusable Definition of Competency or Educational Objective Specification. http://www.imsglobal.org/competencies/ (2002). Accessed 29 February 2012
18. ISTE: NETS for Teachers 2008, http://www.iste.org/standards/nets-for-teachers/nets-for-teachers-2008.aspx (2008). Accessed 29 February 2012
19. Jovanovic, J., Siadaty, M., Gasevic, D., Milikic, N.: IntelLEO Competences Ontology http://www.intelleo.eu/ontologies/competences/spec/ (2011). Accessed 29 February 2012
20. Leinonen, T., Toikkanen, T., Silvfast, K.: Software as hypothesis: research-based design methodology. In: Proceedings of the Tenth Anniversary Conference on Participatory Design 2008, pp. 61–70. Indiana University, Indianapolis (2008)
21. Li, Q., Lau, R.W.H., Shih, T.K., Li, F.W.B.: Technology supports for distributed and collaborative learning over the internet. ACM Trans. Internet Tech. **8**(2), 1–24 (2008)
22. Lombardi, M.M.: Making the Grade: The Role of Assessment in Authentic Learning. EDUCAUSE Learning Initiative (2008)
23. Miller, G.E.: The assessment of clinical skills/competence/performance. Acad. Med. **65**, S63–S67 (1990)
24. Pečiuliauskienė, P., Barkauskaitė, M.: Would-be teachers' competence in applying ICT: exposition and preconditions for development. Informat Educ **6**(2), 397–410 (2007)
25. Põldoja, H., Väljataga, T., Tammets, K., Laanpere, M.: Web-Based Self- and Peer-Assessment of Teachers' Educational Technology Competencies. In: Leung, H., Popescu, E., Cao, Y., Lau, R., Nejdl, W. (eds.) ICWL 2011, LNCS, vol. 7048, pp. 122–131. Springer, Berlin/Heidelberg (2011)
26. Sampson, D., Fytros, D.: Competence models in technology-enhanced competence-based learning. In: Adelsberger, H.H., Kinshuk, Pawlowski, J.M., Sampson, D. (eds.) International Handbook on Information Technologies for Education and Training, pp. 155–177. Springer, Heidelberg (2008)
27. Tiger Leap Foundation: Educational Technology Competency Model. http://www.tiigrihype.ee/?dl=373 (2011). Accessed 29 February 2012
28. Tomberg, V., Laanpere, M.: Implementing Distributed Architecture of Online Assessment Tools Based on IMS QTI ver.2. In: Lazarinis, F., Green, S., Pearson, E. (eds.) Handbook of Research on E-Learning Standards and Interoperability: Frameworks and Issues, pp. 41–58. IGI Global (2011)
29. UNESCO: ICT Competency Standards for Teachers: Implementation Guidelines. http://unesdoc.unesco.org/images/0015/001562/156209e.pdf (2008). Accessed 29 February 2012
30. Wass, V., Van der Vleuten, C., Shatzer, J., Jones, R.: Assessment of clinical competence. Lancet **357**, 945–949 (2001)

Aalto-DD 175/2016

ISBN 978-952-60-6994-4 (printed)
ISBN 978-952-60-6993-7 (pdf)
ISSN-L 1799-4934
ISSN 1799-4934 (printed)
ISSN 1799-4942 (pdf)

Aalto University
School of Arts, Design and Architecture
Department of Media
www.aalto.fi

BUSINESS +
ECONOMY

ART +
DESIGN +
ARCHITECTURE

SCIENCE +
TECHNOLOGY

CROSSOVER

DOCTORAL
DISSERTATIONS