JYU DISSERTATIONS 133

Veera Kenttälä

From Design to Use

Factors of Value Creation in the Usability and Implementation of Digital Learning Technology

UNIVERSITY OF JYVÄSKYLÄ
FACULTY OF INFORMATION TECHNOLOGY

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ABSTRACT

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Learning and teaching with digital technology in classrooms has provided both challenges and opportunities for education providers and teachers for decades. Research on technology integration in education has identified several barriers to technology use that influence teachers' technology integration. These barriers include both technology related barriers and human factors that hinder or prevent the use of technology in teaching and learning. Furthermore, lack of understanding about the complexities of educational use contexts among the designers of learning technologies can render some offered technological solutions unsuitable for educational use. Moreover, the use of digital technologies in education is not necessarily universally accepted or supported by all teachers and many teachers remain hesitant to use technology with their students.

The need for this research stems from two observations made while conducting technical evaluations and user testing on digital learning technologies. Firstly, usability evaluations revealed that the assessed learning technologies contained critical usability issues that hinder their use for teaching and learning purposes. Secondly user testing with teachers showed that there also remain human level barriers (e.g. attitudes and beliefs about technology and own capabilities) that prevent the use of digital technologies for teaching and learning purposes. This thesis addresses both sides by creating a theoretical model that aims to bridge the gap between design and use of learning technologies. On the one hand to provide teachers and students with technology that has been designed to suit their needs and use contexts, and on the other hand to support teachers in finding the courage to use technology and creating digitally oriented and meaningful learning activities for their students.

The results of this research provide theoretically rich and practice-based model that benefit both the design and evaluation of learning technology. Firstly, the results can be used to evaluate and design technological solutions that address the needs of educational use contexts. Secondly the results can also be applied and used in the efforts to provide all teachers with the necessary support for using Information and Communication Technology (ICT) with their students, which ultimately benefits the students by equipping them with the skills they need to successfully navigate the digital environments they face now and in the future. This work also calls for practical long-term applications of the theoretical model from the early stages of development to the implementation and use of the designed technologies.

Keywords: Usability, Teachers, User Support, Learning Technology Design

TIIVISTELMÄ (ABSTRACT IN FINNISH)

Kenttälä, Veera
Suunnittelusta käyttöön – Arvonluonnin tekijät digitaalisen oppimisteknologian käytettävyydessä ja käyttöönotossa
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Oppimisteknologiat ovat tarjonneet viimeisten vuosikymmenien aikana opetukseen sekä haasteita että mahdollisuuksia. Teknologian integroimisessa oppimiseen ja opetukseen on tunnistettu useita esteitä, jotka voivat vaikuttaa opettajien teknologiakäytänteisiin. Teknologian käytön esteisiin kuuluu sekä teknologiaan että ihmisiin liittyviä tekijöitä. Osa näistä haasteista kumpuaa myös oppimisteknologian suunnittelijoiden puutteellisesta oppimiskontekstien tuntemuksesta, minkä vuoksi osa teknologioista saattaa olla opetuskäyttöön kontekstuaalisesti sopimattomia. Myöskään teknologian opetus- ja oppimiskäytön hyödyllisyydestä ja tarpeellisuudesta ei ole yksimielisyyttä opettajien keskuudessa. Osa opettajista on yhä edelleen harkitsevalla kannalla sen suhteen pitäisikö teknologiaa ylipäätään käyttää oppilaiden opetuksessa.

Tarve tälle tutkimukselle kumpuaa kahdesta oppimissovellusten käytettävyyttä arvioitaessa tehdystä havainnosta. Ensinnäkin tätä tutkimusta varten testatut oppimissovellukset sisälsivät käytettävyysongelmia, jotka haittaavat niiden opetus- ja oppimiskäyttöä. Toisekseen käyttäjätestaus opettajien kanssa osoitti, että myös ihmistason esteet voivat vaikuttaa oppimisteknologian käyttöön mm. asenteet ja uskomukset teknologiasta sekä omasta kyvykkyydestä vaikuttavat opettajien valmiuteen käyttää teknologiaa opetuksessa. Tämä työ huomioi nämä molemmat puolet ja pyrkii rakentamaan siltaa oppimisteknologian suunnittelun ja käyttöönoton välille. Pyrkimyksenä on mahdollistaa opettajille ja oppilaille sellaisten oppimisteknologioiden käyttö, jotka on suunniteltu opetuksen kontekstin haasteet ja mahdollisuudet.

Tämän tutkimuksen tuloksia voidaan hyödyntää sekä oppimisteknologian suunnittelijoiden että koulutuksen tuen tarjoan työssä. Ensinnäkin työssä esitelty oppimisteknologian käytettävyyden arviointi viitekehys tarjoaa oppimisteknologian kehittäjille holistisen näkökulman opetuksen kontekstiin soveltuvan teknologian kehittämiseksi. Toisekseen tuloksia voidaan hyödyntää myös opettajien tuen ja koulutuksen tarpeen ymmärtämisessä. Syvän tason tavoitteena työssä on opettajia ja teknologian suunnittelua tukemalla mahdollistaa oppilaiden teknologiaa mielekkäällä tavalla hyödyntävä oppiminen, jotta he ovat valmiita kohtaamaan tulevaisuuden digitaalisten ympäristöjen haasteet. Tämä työ on teoreettinen ja näin ollen sen tuloksien pidempi-aikainen tutkimus, jossa seurattaisiin oppimisteknologiaa varhaisista kehitysvaiheista käyttöön saakka, olisi tarpeen mallin validoimiseksi ja kehittämiseksi.

Avainsanat: Käytettävyys, Opetus, Käytön tuki, Oppimisteknologian suunnittelu

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Jyväskylä, 18.9.2019
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PII Kenttälä, V., Rousi, R. & Kankaanranta, M. (2017). Towards the Learning Technology Usability framework. In Kidd, T., & Morris, Jr., L. R. (Eds.). Handbook of Research on Instructional Systems and Educational Technology (pp. 128-140). Hershey, PA: IGI Global.

PIII Kenttälä, V., Rousi, R., & Kankaanranta, M. (2018). Learning Experience Technology Usability Design framework. In T. Bastianes (Ed.), EdMedia 2018: Proceedings of the World Conference on Educational Media and Technology (pp. 414-423). Association for the Advancement of Computing in Education (AACE).

PIV Kenttälä, V., & Kankaanranta, M. (2017). Courage to learn and utilize ICT in teaching - building understanding of teachers who lack courage. In J. Dron, & S. Mishra (Eds.), E-Learn 2017: World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education (pp. 611-620). Chesapeake: Association for the Advancement of Computing in Education (AACE).

PV Kenttälä, V. & Kankaanranta, M. Building ground for flexible use of educational technology. Manuscript.

1 INTRODUCTION

This thesis explores the currently identified barriers to integration of Information and Communication Technology (ICT) to education and provides theoretical models to overcoming these barriers. In particular, this study examines how through usability design and providing support and training for users, learning technologies can move from being usable to being valuable to their users and thus enabling the integration of ICT to education. This study utilises mixed methods as the main methodological framework to gain an overall view of the complex phenomenon of technology integration into education. The main emphasis in this thesis is, however, on qualitative methods.

Large scale adoption of ICT in education poses a systemic level challenge for change (Vrasidas 2015). Even though significant investments have been made in the field of educational technology over the past decades, this investment has produced only limited impact on school technology integration and ICT is not used in schools as expected (Koba, 2015; McCandless, 2015; Vrasidas, 2015). Moreover, in many schools and classrooms ICT use is still only occasional and the ICT tasks for students utilise very traditional pedagogical approaches (Kenttälä, Kankaanranta & Neittaanmäki, 2017; Salmela-Aro, Muotka, Alho, Hakkarainen & Lonka, 2016). However, the question of technology availability is not simply about the number of computers available for teachers and per student, but also whether those computers are up to date, maintained and easily accessible when needed (Petko, 2012). While ensuring access to technology is necessary, it does not necessarily increase the use of ICT in education and therefore other ICT integration supportive or hindering factors also need to be considered (Brás, Miranda & Marôco, 2014).

Vrasidas (2015) argues that the necessary changes that would enable the large-scale adoption of ICT in education require a solid plan to reform both the curricula and teacher professional development, in order to facilitate this change in education. However, if curriculum change is not accompanied by a solid plan for changes that take into account the practices and the reality of classrooms it is unlikely that the reform will have an effect on them (Cuban, 2001; Smolin, Lawless & Burbules, 2007). Curriculum change should address the potential of ICT changing the content and ways of learning in schools (Vrasidas, 2015). Thus, making increasing understanding of the pedagogical affordances of ICT important to educational reform.

Educational policies and curriculums in different countries over the past decades have also included plans and actions to develop the infrastructure and digital competence of teachers to enable technology integration into education. The first-generation policies for digital education created in the beginning of the 21st century focused mainly on developing technological infrastructure, which was measured through computer per student ratio and access to broadband connections (Conrads, Rasmussen, Winters, Geniert & Langer, 2017; Kankaanranta, 2009). While the computer per student ratio and access to broadband improved, it was observed that a large portion of students were still taught by teachers, who were not digitally confident or supportive of ICT use in education (Conrads, Rasmussen, Winters, Geniert & Langer, 2017; European Commission, 2013). Thus, suggesting that while increasing the infrastructure is necessary to enable basic ICT use in education this might not be enough to achieve integration of ICT in education.

The emergence of second-generation and even third-generation educational policies began a shift towards policy measures that are aimed at supporting and building teachers and students digital competence (Conrads, Rasmussen, Winters, Geniert & Langer, 2017). On a national level digitalisation of education was named as one part of the key projects of the Finnish Government's action plan (Government of Finland, 2018). Moreover, in Finland the basic education National Core Curriculum (Finnish National Agency for Education, 2014) made the need for learning digital skills and the integrational objectives of digital technology in teaching various subject more visible in the core curriculum and also introduced teaching and learning computational thinking as a new content item to Finnish basic education.

Even though the focus in digital policies has been shifted towards not only improving infrastructure, but also supporting schools in ICT integration, there still remain challenges related to ICT infrastructure in schools. Several studies have suggested that the lack of access to technology or amount of technology available in schools is not a barrier in many developed countries (Agyei & Voogt, 2011; Mueller, Wooda, Willoughby, Ross, & Specht, 2008). However, contrary evidence also exists showing that the lack of technology sets barriers to ICT use in schools as do technical difficulties experienced during use (Gil-Flores, Rodríguez-Santero & Torres-Gordillo, 2017; Goktas, Gedik & Baydas, 2013).

While the overall ICT availability in school in a given country can be on a good level, socioeconomic differences may place students, schools and municipalities in unequal conditions. Digital inequality caused by differences in access to technology, skills and use of ICT can still be observed between different regions and municipalities, but also between individual schools (Carter & Reardon, 2014; Hargittai & Hsieh, 2013; Hohfield, 2017). The educational ICT use readiness and amount of up to date and usable technology may differ greatly between individual schools even within one municipality (Hargittai & Hsieh, 2013; Kenttälä, Kankaanranta & Neittaanmäki, 2017). While some schools are well equipped for using digital technologies, other's insufficient infrastructure and the lack of equipment of others may prevent the use of ICT in teaching and learning (Kenttälä, Kankaanranta & Neittaanmäki, 2017; Liu & Pange, 2015). Furthermore, the lack of reliable internet connection and technological equipment or outdated software is seen by teachers as both a barrier and a factor decreasing their motivation to technology use (Marino, Israel, Vasquez, Fisher & Gallegos, 2018).

However, even in schools where the amount of ICT equipment does not pose barriers on technology implementation technology may be underused due to external barriers (e.g. time or training) or internal barriers (e.g. teacher's attitudes and beliefs) (Blackwell, Lauricella & Wartella, 2014; Gil-Flores, Rodríguez-Santero & Torres-Gordillo, 2017; Tsai & Chai, 2012). Furthermore, it has been observed that the education teachers receive, might not prepare them with the necessary skills to successfully integrate technology into their teaching and learning practices in a way that supports 21st century learning and learning of 21st century digital skills (Häkkinen, Järvelä, Mäkitalo-Siegl, Ahonen, Näykki & Valtonen, 2017; Hämäläinen, De Wever, Nissinen & Cincinnato, 2019; van Laar, van Deursen, van Dijk, de Haan, 2017; Kaarakainen, Kaarakainen & Kivinen, 2018; Siddiq, F., Scherer, R., & Tondeur, J. 2016). Even though research settings have shown the positive impacts technology interventions can have on educational practices and learning outcomes, classroom technology use does not meet the potential of technology envisioned by researchers and reformers of education (Niederhauser, Howard, Voogt, Agyei, Laferriere, Tondeur & Cox, 2018; Tondeur, Aesaert, Pynoo, van Braak, Fraeyman & Erstad, 2017).

In order to meet the potential of technology use in education new mindsets (Dweck, 2012) and ways of thinking (Burbules & Callister, 1999) may be required to enable change in practices. Burbules & Callister (1999) argued, already in the turn of the century, that a new way of thinking about technology use in education should be adopted. They suggested moving away from questions focusing on whether a particular technology, such as computers, is good for teaching. These questions in their view represent a way of thinking about technology as being novel or additional to teaching prohibit integration of ICT as similar part of education, as are other familiar elements in classrooms, such as books and blackboards (Burbules & Callister 1999; Burbules, 2018). Burbules (2018) proposes that it should be taken for granted that even all the familiar elements of classroom and social life can be used either well or badly, and therefore the focus on educational technology use should also be moved towards considering how they are used, by whom and for what purpose. Moreover, it has been observed that teachers may lack trust in their own technological skills and other ICT related attitudes and beliefs have an impact on what and how technology is used in their classes (Goode, 2010; Makki, O'Neal, Cotten & Rikard, 2018).

There still remain doubts and confusion about the appropriate use of technology in education (Howard, 2013). The uncertainty of the benefits of integrating ICT to teaching and learning practices may lead to teachers feeling that they might be risking student achievement and teaching time, while using ICT in teaching (Lei, 2010; Lei & Zhao, 2007). Addressing these concerns is necessary to facilitate the move from focusing on individual innovative practices and technologies towards enabling the large scale integration of ICT to education. Furthermore, moving beyond innovation talk and taking an approach that considers technology as a natural and relevant part of teaching and learning could in turn support, making technology more approachable to all teachers (Nardi & O'Day, 1999; Stieler-Hunt & Jones, 2017). While innovative practices are utilised and created by some teachers, they remain unobtainable ideals to many teachers (Voogt, Erstadt, Dede & Mishra, 2013). Therefore, more emphasis should be given to understanding the challenges the teachers, who remain hesitant about technology integration, face in their daily practices.

While innovative practices have been a long time the topic that is often focused on, when talking about teacher's ICT use, this focus may be alienating to some teachers (Stieler-Hunt & Jones, 2017). While some teachers, so called early adopters (Prensky, 2001; Watson, 2006), may easily take new technologies into use, not all teachers fit this category and some may have more reserved attitudes towards technology use for teaching and learning. Culp, Honey, and Mandinach (2005) argue that, while research has focused on technological innovations to support inquiry, collaboration, or modifying the relationship among students and teachers, these innovations are only used by a limited portion of teachers. Furthermore, Means (2010) points out that only few technologies created for learning have succeeded in moving from the use of technology enthusiasts and visionaries towards becoming generally approved technologies among teachers.

When requiring innovative use of ICT from teachers themselves and to facilitate these skills in their students, there may be a discrepancy in the skills and knowledge being taught and provided to teachers and the development design thinking skills may not be supported by ICT training provided (Vongkulluksn, Xie & Bowman, 2018). The lack of design thinking skills and growth-oriented mind-set (Dweck, 2012) may in turn hinder the possibilities of teachers facilitating their students' process of becoming capable digital citizens (Choi, Cristol & Gimbert, 2018).

Defining the skills and competencies for being a capable digital citizen have been the subject of research in the recent years (Carretero, Vuorikari & Punie, 2017; Choi, Cristol & Gimbert, 2018), as these are the skills teachers are expected to teach to their students also teachers' digital citizenship skills need further analysis (Choi, Cristol & Gimbert, 2018). As Choi, Cristol & Gimbert (2018) point out the presupposition that all teachers possess the skills to facilitate digitally connected students in their growth as digital citizens may lead to underestimating the need to also train teachers in these matters. Proposed model (Choi, Glassman & Cristol, 2017; Choi, Cristol & Gimbert, 2018) for understanding the complexity of digital citizenship suggest that there are three levels of conditions for digital citizenship:

1. Necessary but not Sufficient Condition
    - Technical Skills: Lower levels of media literacy and basic open source intelligence skills
2. Distributed and Communicative Condition

- Local/Global Awareness: Ethical consumption of information dealing with local and global issues

3. Collaborative and Cooperative Conditions
   - Networking Agency: Higher levels of media and information literacy
   - Internet Political Activism: Action/transformation-oriented participation
   - Critical Perspective: Rethinking online participation and the Internet.

The demands for being an active and successful digital citizen online in today's society requires the basic knowledge and technical skills, but these are only the preconditions not necessarily the required skills that ensure coping with the modern ever evolving demands of online participation and digital literacy (Choi, Cristol & Gimbert, 2018). Additionally the use of technologies also changes the ways people read and construct knowledge online and thus creating the need to update the definitions of what are the required digital literacy skills in the 21st century (Brand-Gruwel, Wopereis, & Vermetten, 2005; Coiro & Dobler, 2007; Hartman, Morsink, & Zheng, 2010; Kanniainen, Kiili, Tolvanen, Aro & Leppänen, 2019). These demands, however, are not necessarily met by all teachers today, which might also deter them from addressing these issues with their students. Not knowing enough about a given topic, might prevent discussion about the topic altogether.

Furthermore, as McWilliam (2008) points out, not-knowing should be put to use, by learning through making mistakes, not by trying to avoid them by finding and accepting only right answers. This applies also to teachers and like Nardi and O'Day (1999) suggest opportunities and room to participate in the conversation about technology use should also be given to those, who do not yet know it as well, as this could enrich the conversation. Furthermore, Stieler-Hunt and Jones (2017) found out that the innovation focused ICT talk from teachers may be met with resistance from other colleagues. Therefore, understanding how to communicate about technology without shame or hype, might enable all teachers to participate in the discussion and provide valuable insight on the issue.

1.1 Statement of the Problem

The advancements of technology and the continuously changing society places pressure on teachers to prepare their students for future careers that may not yet have been created or even imagined (Anderson, 2008; Dede, 2011). Similarly, teacher education institutes are still struggling to provide preservice teachers the necessary skills and readiness to integrate the use of digital technologies as a natural part of their teaching and learning practices (Hatlevik, 2017; Adams Becker, Freeman, Giesinger Hall, Cummins & Yuhnke, 2016; Freeman, Adams Becker, Cummins, Davis & Hall Giesinger, 2017). Furthermore, this also implies that current inservice teachers might not have received adequate training on how to integrate ICT into their practices during teacher training and therefore the need for further professional development exists.

As was already indicated the large-scale integration of technology to classroom practices still remains to be a goal for educational institutes, instead of actualized practice. The current basic education National Core Curriculum in Finland acknowledges the need for learning with and about digital technologies in all educational levels (Finnish National Agency for Education, 2014). However, as Vrasidas (2015) points out curriculum does not necessarily support the use of technology in education, as teachers feel pressure to cover all other areas of the curriculum. Furthermore, the rapid pace of technological innovation and society challenge teachers to continuously change as they are expected to re-design their teaching and also the learning environments, where learning takes place (Adams Becker, Freeman, Giesinger Hall, Cummins & Yuhnke, 2016). Even though a change is expected from teachers it has been observed that technology can also be used to support antiquated pedagogical practices (Van Braak, Tondeur, & Valcke, 2004; Gil-Flores, Rodríguez-Santero & Torres-Gordillo, 2017). This may, in turn, also be supported by the technology available to teachers, as it is not necessarily designed for education or utilises outdated pedagogical approach (Camilleri & Camilleri, 2019; Lotherington, 2018).

Vrasidas (2015) found out that textbooks and curricula do not necessarily support teachers in ICT integration and there is a lack of for example digital learning objectives that are easy for teachers to adapt and use in classrooms. Furthermore, the pressure to cover the curricula may limit teachers' flexibility in innovating and integrating ICT as a part of their teaching and learning practices (Vrasidas, 2015). Moreover, the lack of suitable quality content may lead in teachers having to spend a lot of time searching for materials or developing their own materials that better suit their students (Vrasidas, 2015). However, as Kankaanranta and Puhakka (2008) noted the implementation of ICT to education does not define teacher's pedagogical orientation. Therefore, the amount of time spent using ICT in teaching and learning, may not signify whether the technology is used in a student- or teacher-centered way and whether the learning activities support the acquisition of 21st century skills.

1.2 Research Questions

This thesis focuses on building understanding of the multifaceted task of designing digital learning technologies for education and using them in classrooms. The aim of this thesis is to create a model that would aid the processes of learning technology designers, support providers and designers and teachers alike. The overall aim in aiding the design of usable educational technology and the implementation of this technology is to ensure that students receive the best possible opportunities to learn with and about technology. This work bridges the way towards meaningful and valuable technological and pedagogical adoption of ICT in education.

This research approaches value creation in learning technology through establishing the basic requirements for digital learning software usability and factors that support and provide users the capability and readiness for using technology in classrooms. Through creating understanding of the process through, which learning technology goes from being simply usable to being valuable to it users is important in order to understand why technology is not currently being used as much as might be possible and even necessary in classrooms. Even the most highly usable and pedagogically sound products require the intent and willingness of teachers to integrate their use into their teaching and learning practices. This matter is explored through two research questions:

1. What factors influence the usability of digital learning technologies?
2. What factors support or hinder the implementation of learning technologies in classroom teaching?

1.3 Structure of the Dissertation

The research questions will be answered and the base for the From Design to Use – framework will be developed through the five articles in this dissertation. As the research questions suggest the model consists of two main components: usability and implementation. The first research question: *'What factors influence the usability of digital learning technologies?'* and design portion of the framework are built through the research conducted in articles PI, PII and PIII. The second research question: '*What factors support or hinder the implementation of learning technologies in classroom teaching?*' and use portion of the framework is discussed and developed in articles PIV and PV that focus on understanding the factors that support and hinder learning technology implementation in schools.

These five articles create the basis (Figure 1) for the From Design to Use model presented in further detail in chapter 9. This model builds on the knowledge gained from previous research about the obstacles to technology integration in teaching this model by examining the factors of usability design and user support together aid in technology integration. This work approaches implementation through two categorisations of teacher encountered obstacles in implementing new technological solutions. Firstly, the model of first- and second-degree barriers as proposed by Ertmer (1999) and later expanded by Tsai & Chai (2012), who added the category of third order barriers to the model. Secondly this categorisation is supported by a second categorisation proposed by Nikolopoulou and Gialamas (2015), who suggest four categories of factors that prohibit teacher's ICT: lack of support, lack of confidence, lack of equipment and class conditions. These categorisations will be discussed in further detail in Section 5.2.

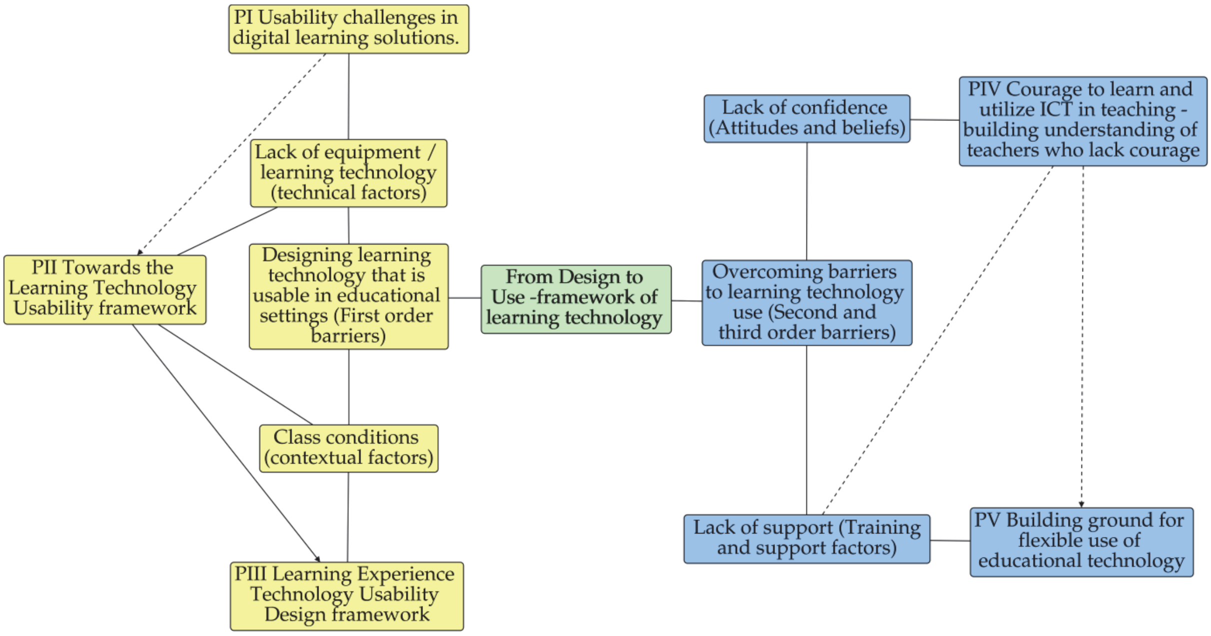

FIGURE 1 The components of the From Design to Use model in the articles.

This dissertation is divided into 9 chapters. In Chapter 2 the research methods utilised in this thesis and the data collection process are introduced. Research methods used in the articles in this thesis are introduced in the articles themselves and will only be presented in the methods section, if they are also used in the compilation part of the work. The data collection describes how and what type of data was collected for each article in this dissertation. Furthermore, in Chapter 3 the terminology used in this thesis in relation to learning technology and ICT is further elaborated. This chapter clarifies the way the terms learning technology and ICT will be used to make a distinction between the various technologies used in education.

This dissertation builds on two sides of learning software development: design and use, which is also visible in the organisation of the sections of the work. Firstly Chapter 4 focuses on the background of the usability design side of the research by introducing user interface usability evaluation from both technical and pedagogical side and introduces the basic methods for evaluating usability. This chapter also brings forth the choices in this dissertation related to the choice of usability evaluation methods. Secondly Chapter 5 sheds light on how the implementation of learning software has been supported and what are the central factors that affect teacher's ICT integration. In chapter 5 the focus on learning specific program is shifted towards general ICT use in classes as there is a wide variety of software that is used in education, even though it has not been developed for learning use.

Chapter 6 focuses on what are the factors that create value for the users (teachers and students) in learning software. Through this background section the path towards the value creation From Design to Use –model presented in Chapter 9 is build.

Chapters 7 and 8 focus on presenting the results and findings from the articles in this dissertation. Firstly, in chapter 7 the work conducted in articles PI, PII and PIII related to the development of learning technology usability design framework is presented. In section 7.1 the technical usability analysis of current learning software conducted in PI is discussed. This work acted as an important first step in understanding the complex nature of learning software design and what usability challenges using the software may pose on users. Then this work was expanded and deepened in PII, which was the first attempt to create a framework for designing usable learning technology as is explained in Section 7.2. The finalised version of the Learning Technology Usability –framework was then created in PIII based on the previous work conducted in PI and PII. This finalised version of the framework is presented in Section 7.3.

Secondly in Chapter 8 the implementation of technology into educational context is explored through examining the results of articles PIV and PV. In Section 8.1 focus is on teachers' courage to use technology alone in their class, which related to the human factors that influence the implementation of learning technology as was discussed in PIV. Section 8.2 presents the results of PV that focuses on building the conditions for flexible technology use in schools.

Chapter 9 builds towards the conclusion of this thesis by combining the knowledge gained from the five articles and presenting the From Design to Use –model of overcoming barriers to ICT integration in Section 9.1. This section illustrates the journey from the early versions of the model into the finalised version and discusses the findings in relation to relevant research. This work is then continued in Section 9.2 that discusses the whole thesis and its contributions to the field and trustworthiness of the research. Lastly in Section 9.3 the conclusions of this work are presented and further research needs are identified and discussed.

2 RESEARCH METHODS AND DATA

This research utilises a mixed methods approach, which combines quantitative and qualitative research methods to data collection and analysis. Mixed methods research is a research design, where qualitative and quantitative approaches are utilised in selecting the used question types, research methods, data collection and analysis procedures (Teddlie & Tashakkori, 2003; Johnson, Onwuegbuzie, 2004). Even though, definition of what mixed methods research is, have been furthered even in the last decades (Johnson, Onwuegbuzie & Turner, 2007) the so-called 'the third methodological movement' as argued by Maxwell (2016) has been used in for example natural and social sciences for a significantly longer time period. As Teddlie and Tahakkori (2003) point out mixed methods research has been used and advocated particularly by social and behavioural scientists since the 1950s. Mixed methods research has been defined by Johnson and Onwuegbuzie (2004, p. 17) as a creative and expansive research form, where researchers may adopt "an eclectic approach to method selection and the thinking about and conduct of research".

Rossman and Wilson (1985) identified that there are three reasons for combining quantitative and qualitative data:

- Combinations enable corroboration and confirmation of each other through triangulation.
- Combinations can be used to enable or develop analysis in order to provide richer data.
- Combinations can be used to initiate new modes of thinking by attending paradoxes that emerge when the two data sources are analysed together.

The purpose of utilising mixed methods research is to create a deeper understanding of the research topic by collecting two types of data that are complementary to each other (Morse, 1991; Plano, Clark, Creswell, Green & Shope, 2008; Rossman and Wilson, 1985). However, Johnson, Onwuegbuzie and Turner (2007) make a distinction between, what they categorise as "pure mixed methods" research and mixed methods research that is dominated by either quantitative or qualitative methods. In this thesis, while both quantitative and qualitative data are utilised the emphasis is on qualitative methods and data.

In this thesis the triangulation of quantitative and qualitative data was related (Figure 2) in order to develop and enable the analysis of the complex issues of designing learning technologies for and implementing them in educational contexts. As Denzin (1978) points out the triangulation of data (multiple sources of data) should be differentiated from methodological triangulation, where multiple methods are utilised in analysing the same set of data.

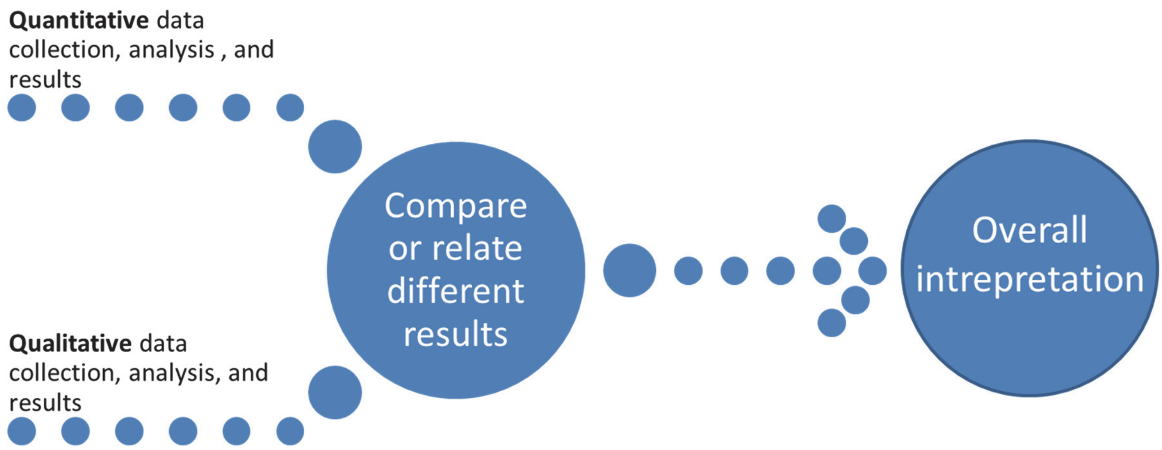

FIGURE 2 Design of triangulation in mixed method research (adapted from Plano, Clark, Creswell, Green & Shope, 2008)

In developing the theoretical framework for usability evaluation presented in Chapter 7 the principles of design research were used (Reeves, 2006; Plomp & Nieveen, 2009), which is also known as design-based research (Anderson & Shattuck, 2012; Stemberger & Cencic 2014) have been applied. Design research has been widely used in the field of educational research from the early 1990s onwards (Brown, 1992; Collins, 1992; Reeves, 2006). It is a systematic methodology that aims to improve educational practices through iterative analysis, design, development and implementation process (Wang & Hannafin, 2005). This collaborative and flexible research method has been utilised in the field of educational technology research, where research and design activities are often inseparable parts of improving current practices and refining design theories and principles (Oh & Reeves, 2010). Design research integrates practical problem-oriented development of reusable design principles in learning environments (Reeves, 2006).

2.1 Content analysis

Content analysis is method that can be applied in analysing and creating understating of a phenomenon using either quantitative or qualitative data

(Downe-Wanboldt, 1992; Schreier, 2012). Content analysis has been developed to be a quantitative way for evaluation of texts, which has been widely applied to literature, film and photography evaluation. Moreover Cole (1988) explains that content analysis can be utilised in analysing messages in multiple forms of communication: written, spoken and visual. The advantage of content analysis is the lack of imposing preconceived categories to the data based on theoretical perspectives (Hsieh & Shannon, 2005). Instead data analysis focuses on understanding the categories that emerge from the data (Downe-Wanboldt, 1992; Hsieh & Shannon, 2006). Furthermore, it is then up to the researcher to depict the relevant theoretical perspectives in the current study (Hsieh & Shannon, 2006; Payne & Payne, 2004).

Even though content analysis has been created as a way of quantitative evaluation, the focus has later shifted towards qualitative research, which also deals with interpretation and subjective meanings (Payne & Payne, 2004). Furthermore, the introduction of interpretations to content analysis has raised the need to contextualise the research as there are several interpretations and ways to read any text (Sailkind, 2010). Therefore, it is important that when utilising content analysis that the research questions are in a transparent way related to the analysed data (Sailkind, 2010). In qualitative studies sampling strategy is not usually selected based on the need for generalisability of the results, but based on the methodology and topic (Elo, Kääriäinen, Kanste, Pölkki, Utriainen & Kyngäs, 2014; Higginbottom, 2004). Qualitative sampling strategies include purposive, theoretical, selective, convenience, within-case and snowball sampling Furthermore, the sample should be appropriate and the participants should be those, who have knowledge or best represent the topic of the research (Creswell, 2017; Higginbottom, 2004; Polit & Beck, 2004).

2.2 Case study

Case study research has been given a central position in various disciplines including: business, education, history, psychology and sociology (Gerring, 2006). Yin (2017) describes case study as an empirical inquiry into a contemporary phenomenon within real-life context, where the boundaries between context and phenomenon are not clearly evident. Both qualitative and quantitative research methods can be utilised while conducting case study research (Yin, 2017). In case study research the phenomenon can be studied using multiple methods and addressing the perspectives of multiple shareholders (e.g. individual and organisational) to further explain a complicated phenomenon (Yin, 2017). Case studies commonly utilise 'how' and 'why'-questions in an attempt to describe, explain and explore the studied case (Yin, 2017). According to Bhattacherjee (2012) the strengths of case study research include building and testing theories and having the possibility to modify research questions in middle of the research process. Furthermore, as case study research utilises a flexible design strategy, data collection can be incremental and if the collected data is insufficient, new data collection can be planned (Andersson, & Runeson, 2007; Runeson & Höst, 2009).

The subject of study in case study research is an individual case and the aim is not to explain the relationships between phenomenon, test hypothesis or make generalisations of the studied phenomenon (Anttila, 1996; Yazan, 2015). Instead the aim is to describe the studied phenomenon in exactly and truthfully (Hirsjärvi, Remes & Sajavaara, 2004; Yazan, 2015). As a research methodology case study can be considered to be suitable in software engineering research, since case study research offers the possibility to study contemporary phenomena, which are hard to difficult to study in isolation (Runeson & Höst, 2009). As case studies differ from controlled and analytical empirical studies, they have been criticised for being less valuable, prone to researcher bias and impossible to generalize (Runeson & Höst, 2009). According to Runeson and Höst (2009) case studies are a trade-off between the level of realism and control. Therefore increasing the level of control in studies conducted in real world settings may hinder the level of realism (Runeson & Höst, 2009).

However as Bhattacherjee (2012) points out there are also weaknesses identified in case study research in regards to internal validity and the dependence of the quality of the results relying on the researcher's abilities. Also the contextualisation limits the possibilities to generalise the results to other contexts or larger population (Bhattacherjee, 2012; Runeson, & Höst, 2009). This critique can be addressed through application of proper research methodology and practices, but also by considering that the knowledge also has value, not only the statistical significance of the results (Flyvbjerg, 2007; Lee, 1989; Runeson & Höst, 2009). The concerns about the validity and trustworthiness of this research are addressed in detail in Chapter 9.2.

2.3 Data collection

The data for the articles in this thesis consisted of both quantitative and qualitative data. Firstly, articles PI, PII and PIII utilised qualitative data that was coded to create and examine content categories. The qualitative data consisted of data from heuristic evaluations utilised in PI, expert evaluation data utilised in PII and research article analysis utilised in PIII. Secondly the quantitative survey data was utilised in articles PIV and PV. Moreover, in article PV the knowledge gained through quantitative data analysis was complemented by qualitative analysis of relevant open-ended questions in the survey. Lastly in building the From Design to Use -model combining the knowledge from all the articles and relevant research content analysis was used to analyse the data.

Data collection for this research consisted of several methods as can be seen in Table 1. Firstly, the design of learning technologies portion of this research, presented in articles PI, PII and PIII, utilised an iterative process where future data collection was guided by the knowledge gained from the previous research. The heuristic evaluation data utilised in PI built the understanding that in order for the method to be applicable to learning technology evaluation the categories needed to adapt for this purpose. This knowledge guided the addition of international expert evaluation data on learning technologies, from experts in their various fields and learning context, to the previous knowledge in PII. From the larger expert evaluation data and framework (see Mäkelä, 2015) this research utilised the open-ended answers experts had given in the design portion of the evaluation form. The coded qualitative expert evaluation data was utilised in creating and categorising the items that would need to be covered in evaluating and designing usable learning technology. Furthermore, the knowledge gained from creating the preliminary framework led to next step in the research, where the explanatory power of the framework was increased by examining previous research literature in the field and conducting a content analysis on the contextual aspects of educational technology use in PIII. This work then concluded the work on the learning technology usability framework in the form that is presented in Chapter 7.

TABLE 1 Data collection methods and tools employed in each article

<table>
<tr><th>Article</th><th>Methods</th><th>Focus on</th></tr>
<tr><td>PI</td><td>Heuristic evaluations of learning solutions</td><td rowspan="3">Design and evaluation of digital learning technologies</td></tr>
<tr><td>PII</td><td>Expert evaluations of learning solutions</td></tr>
<tr><td>PIII</td><td>Literature review and content analysis</td></tr>
<tr><td>PIV</td><td>Online Survey for teachers</td><td rowspan="2">Implementation and use of digital learning technologies, support and training offered and required by teachers</td></tr>
<tr><td>PV</td><td>Online Survey for teachers and principals</td></tr>
</table>

The data and understanding gained from the design aspects of learning technology supported also the addition of implementation and use related data. The data for articles PIV and PV were collected through a large online survey conducted in 2016 for teachers and principals. In PIV only the teacher survey data was utilised and analysed as the focus in the article was on understanding the teacher-level barriers of classroom technology use. This work then led to the addition of principal survey data to complement and further explain the needs and reality of learning technology use context and users in PV. The principal and teacher surveys were designed in a way that they complement each other by approaching the same themes from different point of views. However, they only shared a few identical questions and therefore comparisons between teacher and principal surveys could only be done on a limited amount of questions. Therefore the main emphasis is on understanding how these two data sets complement each other in creating understanding of schools’ technology use barriers, rather than comparing their results to each other. The combination of these data collection methods and multiple data sources has provided a rich view into the complexities of learning technology design and use in the intended use context.

3 LEARNING TECHNOLOGY

In this study the term learning technology, or digital learning technology, is defined as software that has been designed to be used for education (i.e. in teaching and/or learning). This software category, also known in research as learning solutions, is utilised, when talking about this category of software (Kankaanranta & Kangasniemi, 2015; Mäkelä, 2015). The term digital learning technology will be used, when considering the usability aspects of technology (see Chapter 7) to create a distinction from, for example productivity software used in education that has not been designed for educational use. However, as it is common that technology used in classrooms is not necessarily intended or designed for educational context (Hsu, 2011), therefore this side of technology use in educational contexts must also be addressed, when considering technology integration.

Moreover, to ensure that the focus of technology being described in this dissertation is clear the term digital learning technology is used when describing and discussing technology that has been developed especially for educational and learning purposes and its various contexts, out of which formal educational settings such as classrooms is one. When general technology use is discussed the term, ICT is utilised. Furthermore, when the technology being described might include, but is not limited to digital technology intended for educational settings and learning purposes the term Information and Communication Technology (ICT) is used.

This distinction is necessary to create understanding and distinction between, the technology that is designed for educational context and the technology that is actually used, which might also include other technologies. Assessing the educational context suitability of software products that have been to for example office work (productivity software), even though also used in education and learning would not necessarily provide the necessary understanding of the usability challenges that are particular and common to educational technology use. As the focus of this research is to understand the intricacies of designing technology that is intended to be used in educational context it is important to make this distinction.

The amount and variety of learning technologies available to teachers and learners has increased over the past decades. Since the first use of the term serious games by Abt in the 1970's (Abt, 1987) different types of games (serious games and edutainment) used in education have been widely researched (e.g. De Lope & Medina-Medina, 2017; Djaouti, Alvarez, Jessel & Rampnoux, 2011; Garris, Ahlers & Driskell, 2002); Prensky, 2003; Wilkinson, 2016). When considering learning games that have been implemented and used globally, such as GraphoGame (McTigue, Solheim, Zimmer, & Uppstad, 2019; Richardson & Lyytinen, 2014) it can be noted that they have a very specific use context and learning content. In the case of GhaphoGame, which is a research based game developed originally for observing reading acquisition, the use context and users of the game have been defined to those learners, who are learning to read (Lyytinen, Erskine, Kujala, Ojanen & Richardson 2009). Moreover the specified nature of learning technologies has also led to more content specific fields of research, such as Computer Assisted Language Learning (CALL), which focuses on the technologies that have been designed on language learning (Beatty, 2013; Savas, 2019). This specialisation of fields of research also illustrates the importance of understanding the demands and qualities of the intended context of use, when designing technologies for learning.

In addition to serious games and other technologies developed for learning, teachers and schools utilise a wide variety of technology that is not designed or intended for educational use. While technology is used by teachers to prepare their own teaching, it does not automatically correspond with the number and quality of ICT-based activities they create for their students (Vrasidas, 2015). Commonly teachers use general purpose research and productivity applications, including word processing and presentation software and internet browsers, when giving instructions or providing research and production activities for their students (Dunleavy, Dexter, & Heinecke 2007; Kenttälä, Kankaanranta & Neittaanmäki, 2017). Even though assessing the usability of this type of software might be useful in general, evaluating their usability in relation to their educational context applicability is not necessarily relevant, as they have not been designed to be used for learning purposes. Nevertheless, as they are commonly used in education, when looking at how to support teachers in integrating technology to their classroom practices this category of software also needs to be acknowledged and analysed.

Furthermore, as Cheung and Vogel (2013) point out, for example Web 2.0 applications (e.g. online wikis and discussion forums) brought many new possibilities for collaborative learning, even though the applications were not designed with teaching and learning in mind. Therefore, limiting the support aspect of this research only to software that is designed for education would not be justified, since many studies show that simple word processing software is one commonly used software in formal teaching environments for teaching and learning purposes (Dunleavy, Dexter, & Heinecke 2007; Hsu, 2011). Moreover, it has been suggested that whether simple office software is used in teaching and learning or not may give some indications about teacher's overall technology use and attitudes towards technology use in education (Hsu, 2011; Vrasidas, 2015). Therefore, the approach to technology use and support in this research takes into account all software used for learning and teaching purposes.

Regardless of the original intended use and user groups of software the technology that is currently used in classrooms today is taken into consideration, when analysing and offering the support and professional development teachers receive and would require to integrate technology to their practices. Furthermore Vrasidas (2015) defines ICT integration to be achieved when teachers develop ICT-based activities for their students aimed at aiding them to achieve specific learning outcomes. This view does not address whether the technology is designed for education, but applies to all technology that can be used to aid learners to achieve specific learning outcomes.

4 USABILITY

Usability of software has been widely studied over past decades and several methods for evaluating the usability of software have been developed. Usability of a product as defined in the ISO standard 9241-11 (International Organization for Standardization, 1998) is:

> The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use.[1]

The definition includes the idea that when assessing usability, it is necessary to specify the goal users are trying to effectively achieve while using the product (International Organization for Standardization, 1998). Furthermore, when considering the satisfaction user experiences while using the software or product the context of use is specified (Bevan, Carter & Harker, 2015; International Organization for Standardization, 1998). Thus, making the context of use relevant when evaluating the usability of any product.

This definition has been widely adopted as the basic definition of usability by research and industry alike (Bevan, Carter & Harker, 2015). In the recent decade the term usability has been in many contexts seen as being too limited to the technological aspects of software user interfaces and the measurable outcomes of interaction with the software and therefore wider approach called User Experience (UX) has been more widely adopted over the past years (Bevan, Carter, & Harker, 2015; Garrett, 2010). User experience has for long been lacking a widely accepted basic definition. Garrett (2010) defines user experience as the experience a product creates, when it is used by people in real world use contexts. Moreover, revision to the ISO 9241-11 standard was made in 2018 (International Organization for Standardization, 2018) and user experience was defined as:

> the set of "user's perceptions and responses that result from the use and/or anticipated use of a system, product or service

However, as Hassenzahl (2004) explains conceptually user experience is subjective and varies when user uses a product. Hassenzahl (2004) indicates that user's perceptions and emotional or behavioural responses are apparent

[1] International Organization for Standardization, 1998

consequences of interacting with the product. However, due to this slightly undefined and subjective nature of user experience in design and evaluation, this research focuses on evaluating and designing the usability of learning technology. Krug (2014) argues that the commonly applied method of finding out what an average user likes should not be used as the basis for web design, since no average user actually exists and all web use is in essence idiosyncratic as all users are unique. This aim to please an average user may lead to the simplification of web usability as series of 'good' and 'bad' design choices. While Krug (2014) acknowledges that there are many choices known to be unusable, usable web-design is a more complex matter. The focus should be on creating solutions, which fill user need, to be logical, well executed and tested (Krug, 2014).

Some confusion still remains about the definition of usability as the term user experience has been widely adopted in the recent years in a way that also encompass a lot of the aspects traditionally belonging to usability evaluation. In some definitions the standard definition of usability (International Organization for Standardization, 1998) can be seen as one vital part in creating the user experience (UX) of the software user interface (Garrett, 2010). However, as Bevan, Carter and Harker (2015) point out the original meaning of user experience had a strong emphasis on the emotional experience of users. Moreover Bevan, Carter and Harker (2015) explain that the viewpoints in these two concepts also differ in goal setting. Usability deals with goals that are shared by a particular user group, whereas user experience is more concerned with the goals of individuals (e.g. acquiring new knowledge and skills, communicating personal identity and creating pleasant memories). Furthermore, the revised ISO 9241-11 (International Organization for Standardization, 2018) addresses this issue and brings the standard definition of usability closer to the way user experience is commonly used with the inclusion of personal factors for individuals to the definition (Bevan, Carter and Harker, 2015). Therefore, the term usability is used in this work to describe the developed framework, which takes into account both the individual and social learning experience aspects of designing learning technologies for education.

When considering the usability of learning technology two sides are traditionally seen to exist in the evaluation: technical and pedagogical usability (Nokelainen, 2006). Technical usability can be seen as the first threshold for successful educational software as a reliable and logical operation of the software allows users to focus on their main task, learning, while using the software. There are many ways of evaluating usability in software user interfaces including: cognitive walkthroughs (Nielsen 1994b; Polson, Lewis, Rieman & Wharton 1992; Wharton, Rieman, Lewis, & Polson, 1994), time-testing (Rubin & Chisnell 2008), error counting (Doubleday, Ryan, Springett & Sutcliffe 1997), System Usability Scale (Brooke, 1996) and heuristic evaluation (Nielsen 1992; 1994a). Further, there are several alternative criteria for assessing usability (Folmer & Bosch 2004; Hvannberg et al. 2007). As was suggested by Nielsen (1994b) best coverage of usability issues present in software can be found with the combination of user and expert evaluation methods.

However, in some cases usability evaluation is not given very high importance in software development and evaluation methods are chosen and applied based on how efficiently they use available resources (Albion, 1999). This might not necessarily lead to selecting the most suitable evaluation methods for the product, however, as was shown by Nielsen (1992) heuristic evaluation conducted by limited number of experts is one cost efficient way to find a significant amount of severe usability problems from the software. Nielsen (1992) suggests that at least three experts should be used, however, when using the so-called double-experts, who also have experience about the used technologies two evaluators, may be considered a sufficient amount for conducting heuristic evaluation. In this thesis Heuristic evaluation (Table 2) was chosen as the method to analyse learning technology technical usability (PI).

TABLE 2 Nielsen's (1995) ten usability heuristics

Heuristic	Description
Visibility of the system status	The system should always keep users informed about what is going on, through appropriate feedback within reasonable time.
Match between system and the real world	The system should speak the users' language, with words, phrases and concepts familiar to the user, rather than system-oriented terms. Follow real-world conventions, making information appear in a natural and logical order.
User control and freedom	Users often choose system functions by mistake and will need a clearly marked "emergency exit" to leave the unwanted state without having to go through an extended dialogue. Support undo and redo.
Consistency and standards	Users should not have to wonder whether different words, situations, or actions mean the same thing. Follow platform conventions.
Error prevention	Even better than good error messages is a careful design which prevents a problem from occurring in the first place. Either eliminate error-prone conditions or check for them and present users with a confirmation option before they commit to the action.
Recognition rather than recall	Minimize the user's memory load by making objects, actions, and options visible. The user should not have to remember information from one part of the dialogue to another. Instructions for use of the system should be visible or easily retrievable whenever appropriate.
Flexibility and efficiency of use	Explanation: Accelerators -- unseen by the novice user -- may often speed up the interaction for the expert user such that the system can cater to both inexperienced and experienced users. Allow users to tailor frequent actions.
Aesthetic and minimalistic design	Dialogues should not contain information which is irrelevant or rarely needed. Every extra unit of information in a dialogue competes with the relevant units of information and diminishes their relative visibility.
Helping users recognize, diagnose, and recover from errors	Error messages should be expressed in plain language (no codes), precisely indicate the problem, and constructively suggest a solution.
Help and documentation	Even though it is better if the system can be used without documentation, it may be necessary to provide help and documentation. Any such information should be easy to search, focused on the user's task, list concrete steps to be carried out, and not be too large

However, in the context of digital learning solutions, analysing only technical usability is not enough as was understood in PII. Thus, pedagogical usability also needs to be considered and addressed. Attempts have been made to create models and methods to evaluate and test the pedagogical usability aspects of educational technology (e.g. Granic, A., & Cukusic, 2011; Hadjerrouit, 2010; Nokelainen, 2006). Mayes and Fowler (1999) argue that the technical usability inspection methods developed for other software cannot be directly applied to educational software. According to Mayes and Fowler (1999) usability of technology is not a prerequisite of deep learning and more emphasis should be placed on supporting learning about and with the software. Similarly, Nokelainen (2006) suggests that, if there is an error situation caused by unexpected user actions, the software should help the user to use the software in a way that prevents the same error from happening again. However, this does not negate the need for the basic functions of the software being usable and easily learnable for the user (Nokelainen, 2006).

Nokelainen (2006) created a heuristic evaluation model for evaluating the pedagogical usability of learning solutions, which has been used in several later studies focusing on learning technology usability. Later on, Hadjerrouit (2010) created a similar framework for assessing digital learning solutions that was based on earlier work by Nokelainen (2006). However, as technical heuristic evaluation methods (Nielsen, 1994b) focus only on the technical aspects of the software, also pedagogically oriented models build on the same foundation may adopt a narrow view on the complexity of educational software usability. This current study attempts to address this gap by addressing more holistically both the technical and learning related complexities of the environment, where learning technologies will be used (Chapter 9).

Furthermore, the introduction of tablets in education seemed, at least in some cases, to provide a more approachable use environment for teachers and in turn to increase their use of ICT in their teaching and learning processes (Klein, Gröber, Kuhn, & Müller, 2014; Wang, Wu, Chien, Hwang & Hsu, 2015). While computers provide a complex and sometimes unreliable environment of use, tablets provided a more stable and controllable environment even for the teachers, who otherwise doubted their own technological skills (Kenttälä, Kankaanranta & Neittaanmäki, 2017). Moreover, tablets offer some affordances that traditional computers may not offer (Vrasidas, 2015). For example in teaching and learning physics tablets and smartphones offer possibilities for measuring and observing physical variables and tests in a way that is both tangible and easily approachable for students, but would not necessarily be possible with traditional computers (Kenttälä, Kankaanranta & Neittaanmäki, 2017; Klein, Hirth, Gröber, Kuhn & Müller, 2014; Klein, Gröber, Kuhn, & Müller, 2014; Wang, Wu, Chien, Hwang & Hsu, 2015). This type of activities might simply not be manageable with a computer and therefore understanding the affordances of technology is important, for also understanding the extent of their usability in education.

Therefore, when talking about technology use in classrooms it needs to be taken into consideration that technology not only has to be usable, but it also needs to be useful for the users, either by providing value to the teachers (e.g. saving time and effort or creating new opportunities for teaching and learning) or to their students (e.g. increased motivation or learning results) and this value creation will be further discussed in chapter 6. This study addresses this complex issue through creating understanding of the basic requirements of technology that are usable and suitable to the intended use and then moves on to analysing the user related factors that create the feeling of meaningful and valuable technology.

5 IMPLEMENTATION OF LEARNING TECHNOLOGY

Successful integration of ICT into education has been researched for nearly as long as technology has been available (Instefjord & Munthe, 2017). The social environment in the educational setting creates challenges for the implementation and integration of ICT into education. The role of teachers has been changing over the past decades from authoritative figures towards more flexible and constructive facilitators of student learning (McWilliam, 2008). However, this shift from behaviourist to constructivist pedagogy that has been going on from the 1970's onwards has not necessarily changed the role of teachers as much as expected (McWilliam, 2008; Helsper & Eynon, 2010; Kale & Goh, 2014). While past decades have seen the rise of positive and error-welcoming pedagogies, these approaches may not have revolutionised the internal or external role expectations placed on teachers (McWilliam, 2008; Routarinne, 2007). Individual teachers may still uphold the view that as teachers they need to control the class and be a traditional authority figure that has all the answers (Dweck, 2012; Kale & Goh, 2014; Routarinne, 2007).

Letting go of control by, for example, utilising the aid of students, who are more skilled in ICT related matters, may cause anxiety and even fear in teachers, who assume a traditional role of an authoritative teacher (Hsu, 2011; McWilliam, 2017; Routarinne, 2007). Moreover, there is also some indication that teachers, who otherwise utilise student-oriented pedagogical approaches may use a more limited and teacher-oriented pedagogical approach, when using ICT in their teaching (Hsu, 2011; Inan & Lowther, 2010; Prestridge, 2012; Tondeur, van Braak, Ertmer & Ottenbreit-Leftwich, 2017). However, as results from Ertmer, Ottenbreit-Leftwich, Sadik, Sendurur and Sendurur (2012) indicate teachers with student-centred pedagogical beliefs were generally more likely to also integrate ICT more and utilize student-centred ICT practices.

In many studies teacher-centred pedagogical practices utilised by teachers have been seen as something that might also affect the way teachers use technology. Furthermore, it has been observed that some teachers, who otherwise utilise learner-centred pedagogies, such as inquiry-based learning (Hmelo-Silver, Chinn, Chan, & O'Donnell, 2013) might not assign their students with constructivist learning activities (Liu, 2011), but return to using more traditional pedagogical choices and activities (Van Braak, Tondeur, & Valcke, 2004; Gil-Flores, Rodríguez-Santero & Torres-Gordillo, 2017). Suggesting that introduction of technology to teaching may limit some teacher's pedagogical flexibility. Liu (2011) suggests that teachers who are overly focused on academic achievement or lack understanding of technology integration do not provide their students with constructivist learning activities, even though they would do so in their non-technology related practices.

Simply adding technology and software at teacher's disposal is not a significant action in order to increase technology use in classroom teaching (Dunleavy, Dexter & Heinecke, 2007; Vrasidas, 2015). When technology use in classrooms has been increased it has according to research been used in ways that support teacher's current teacher-oriented pedagogy (e.g. Palak & Walls, 2009; Sheffield, 2011). However, the lack of necessary resources or access to required networks, will prevent the use of technology, even if second-order barriers would have been overcome and therefore they need to be addressed also in this study. Furthermore, Williams, Coles, Wilson, Richardson and Tuson (2000) observed that in many cases teachers may be inclined to report external hindering factors (e.g. infrastructure related), which might hide internal factors such as attitude and experience related measures in interpretive research. However, there are also teachers who express that ICT has offered them the possibility to actualize their pedagogical beliefs in their teaching with the aid of ICT (Antonietti & Giorgetti, 2006; Kynäslahti, 2002). Yue, Law and Wong (2003) suggest that the creation and provision of hardware and software used that influence and empower teachers are important factors in successful integration of ICT into education.

5.1 Teacher technology integration

First step towards personal use of technology is gaining familiarity with the technology in order to reduce feelings of anxiety and fear (Howard, 2013). The negative affective responses of humans are more immediate and stronger, than their analytical responses (Slovic, Finucane, Peters & McGregor, 2004). Thus, suggesting the need to address the affective responses to technology first to enable teachers to evaluate the benefits integration of technology potentially offers (Howard, 2013). To relieve these anxieties related to technology use it has been suggested that teachers expressing such responses need to gain focused positive experiences to reduce their anxiety (Wilfong, 2006). The creation of positive experience supported with conscious risk communication about technology integration can help teachers overcome their initial affective responses and evaluate the technology integration more analytically (Howard, 2013; Todman & Drysdale, 2004).

> The uncertainties around technology, teaching and change are not likely to be resolved in the near future. In fact, it is certain that teaching and technology will continue to

> change, thus uncertainty will only increase; and, with change, risk will always be present. The key to helping teachers fruitfully engage with technology and change is to understand what is actually being risked, and what they perceive is at risk. Only with this understanding can teachers be helped to make clear decisions about technology and teaching, rather than resisting change with the heat of emotion.[2]

When faced with unfamiliar or fear inducing situations it has been seen that teachers may limit their expression or pedagogical choices to retain more control over the situation than they would do in conditions that are more familiar to them, to avoid risk of losing authority or face in front of their students (Dweck, 2006; Howard, 2013; Routarinne, 2007). This may in turn lead to using more teacher-oriented activities when working with technology that is not yet familiar to the teacher. Furthermore, when moving towards ways of teaching that would require teachers to change their current teaching practices might cause additional stress and resistance towards integrating technology into their teaching (Howard, 2013). As Wood, Mueller, Willoughby, Specht and Deyoung (2005) noticed teacher's confidence or comfort with technology leads to a greater ICT integration success in teaching.

Teacher's acceptance of technology is important for successful implementation and integration of ICT in education (Bourgonjon, De Grove, De Smet, Van Looy, Soetaert & Valcke, 2013; Valtonen, Sointu, Kukkonen & Mäkitalo, 2018). There are several ways to evaluate and assess user's willingness to integrate technology into their practices. One commonly used model is the Technology Acceptance Model (TAM) (Davis, 1989; Venkatesh & Davis, 2000; Venkatesh & Bala, 2008), which considers technology acceptance to be determined by two major factors: Perceived Usefulness and Perceived Ease of Use. Other models include the Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh, Morris, Davis & Davis, 2003) and Technological Pedagogical Knowledge (TPACK) framework (Mishra & Koehler, 2009; Koehler, Mishra & Cain, 2013).

Out of these examined research frameworks the TPACK model was chosen and is used in article PIII (Section 7.3) to enforce the contextual aspects of the usability design. This selection was done to further understand the complexities of learning technology use contexts, which out of the examined models, was most widely addressed and described in TPACK research. As there remains some ambiguity in terms of the definition and use of context in TPACK research (see e.g. Rosenberg & Koehler, 2015), article PIII also addresses this issue, through systematic examination and categorisation of the elements of educational technology use context.

Teachers differ in their technology adoption strategies. Loveless, Burton, and Turvey (2006) observed with student teachers that their pedagogical beliefs could be described as 'play as starting point', which provides room for compromises and improvisation based on students reactions and the main aim is not to offer too much guidance, but to facilitate their creativity with ICT rather than offer too much instructions on ICT use. Similar attitudes can be observed in the so-called early adopters (Watson, 2006), who are teachers that are comfortable with taking new

[2] Howard, 2013, p. 370.

technologies into use early on and testing their use in education. However, focus in research is often placed on the early adopters and innovative use of ICT, which may leave the more reserved and slowly reacting majority of teachers unheard in the ways how ICT is and could be integrated in education. These early adopters may be a good way to also introduce other members of the school community to new technologies and innovative practices. However, as Voogt, Erstad, Dede and Mishra (2013) point out the discourse on innovative technology supported pedagogical practices are often focused on stories of personal heroism, of teachers who selflessly sacrifice a part of their life to benefit student learning. While being good stories, the model of educational improvement is un-scalable to many teachers (Nardi & O'Day, 1999; Voogt, Erstadt, Dede & Mishra, 2013).

Moreover, discussion about technology use in education that is based on innovative use of ICT may alienate some teachers from the discussion of educational technology use altogether and hinder the possibility of opening a broader discussion about the topic (Nardi & O'Day, 1999; Stieler-Hunt & Jones, 2017). Furthermore, as Stieler-Hunt and Jones (2017) observed in their research not all teacher colleagues are open to taking ICT related ideas from early adopters. Their research showed that the eager and positive attitudes of early adopters might be confronted with negative attitudes and even resentment from colleagues. Moreover, the power of social pressure in schools should also be acknowledged as it may influence technology integration (Ertmer & Ottenbreit-Leftwich, 2010; Howard, 2013; Zhao & Frank, 2003). On the one hand Lawrence and Tar (2018) argue that the integration of ICT can be supported by teachers' positive attitudes towards ICT and their knowledge of ICT. On the other hand, they acknowledge that factors such as the lack of ICT knowledge, resistance to change, the lack of time and the complexity of integrating ICT to education can hinder or prevent ICT integration.

Teaching takes place in social situation and social risk-aversion may also in part affect teacher's technological choices (Howard, 2013; Routarinne, 2007). The social pressure the teachers face in schools also poses challenges to school leadership in relation to clearly communicating the expectations of technology integration (Howard, 2013). Furthermore, the close alignment of learning objectives and general disciplinary culture in the school, to the expectations of technology use has been identified important to technology integration in particularly secondary schools (Artmeva & Fox, 2011). While clearly communicated expectations are important, to achieve them appropriate support should also be provided (Law, Pelgrum & Plomp, 2008).

Teachers do not necessarily use technology to achieve new learning objectives but they use it in the hope to better achieve objectives with technology compared to traditional teaching methods to facilitate the achievement of present objectives (Zhao & Cziko, 2001). Ertmer (2005) states that teachers may at times take up new technology into their teaching without making changes in the pedagogy that guides classroom action. Moreover, teachers' resistance towards the implementation of technology is likely to increase if the use of the new technology also requires changes in pedagogy (Zhao & Cziko, 2001).

5.2 Barriers to technology integration

There have been numerous studies that examine and categorise the barriers to technology implementation in schools (e.g. Ertmer, 1999; Gil-Flores, Rodríguez-Santero & Torres-Gordillo, 2017; Hew & Brush, 2007; Makki, O'Neal, Cotton & Rikard, 2018; Nikolopoulou and Gialamas, 2015). Veen (1993) identified that there are school level and teacher level barriers (Veen, 1993). Hew and Brush (2007) divided barriers into six main categories: knowledge and skills, resources, attitudes and beliefs, institution, assessment and subject culture. Ertmer (1999) divides the barriers to two levels: first-order (external) and second-order (internal) barriers (Ertmer, 1999; Sang, Valcke, Van Braak & Tondeur, 2010). Ertmer's model was later on build upon by Tsai & Chai (2012), who added a third category of third-order (design) barriers to the model. In this thesis the categorisation of barriers by Ertmer (1999) and Tsai & Chai (2012) is utilised to categorise the barriers to ICT use and integration in education.

First-order barriers are challenges that consist of resources and necessary external preconditions that make technology use in classrooms possible such as technological equipment and access to training (Ertmer, 2005; Ertmer, Ottenbreit-Leftwich, Sadik, Sendurur & Sendurur, 2012). Even though addressing these external barriers is necessary to enable technology use, it needs to be acknowledged that schools, as workplaces, are complex stages, where emotions and attitudes also influence decisions (David, 2016).

Second-order barriers are internal human level barriers that affect whether technology is used in classroom practices such as teacher attitudes and beliefs (Ertmer, 2005; Ertmer, Ottenbreit-Leftwich, Sadik, Sendurur & Sendurur, 2012). Intrinsic factors such as teacher beliefs and attitudes, knowledge and skills may play a significant role in determining whether technology is used in their classes (Vongkulluksn, Xie & Bowman, 2018). As was pointed out by Kim, Kim, Lee, Spector and DeMeester (2013) that while teacher beliefs have been widely studied in several countries in relation to ICT use, the definition of teacher beliefs varied and many studies examining teacher beliefs in relation to ICT integration, adopted a narrower definition of teacher beliefs focusing only ICT related beliefs. Moreover, they suggest that along with finding out what are the technology related beliefs of teachers, it is also important to understand teacher's fundamental beliefs about what is important in teaching and learning regardless of the particular technology being used.

Ertmer (2005) describes first order or first-order barriers as barriers that are easier to fix, as they can be addressed without the need for teachers to change their existing beliefs or changing structures. As Ertmer (2005) explains changes related to first-order barriers, unlike second-order barriers, are also reversible. The changes made such as adding technological infrastructure and computers can be reversed, but changes made to attitudes and beliefs are at least to some degree permanent (Ertmer, 2005). However, as Ertmer (2005) points out the change process involving second-order barriers is irreversible even though returning to old routines and habits can be difficult (Brownlee, 2000). However, while this type of change may be instant it can also change back unwillingly and the old habits re-emerge into teaching and learning practices (Prestridge, 2012). Research has shown that teachers are more willing to overcome technological problems, if they believe that using the technology will aid student learning (Badia, Meneses, Sigalés & Fàbregues, 2014).

To further explain the complex matter of teacher technology integration the addition of a new category of third-order barriers to the existing two levels of barriers has been made by Tsai and Chai (2012). These third-order barriers would adhere to teachers design thinking skills (Koh & Chai, 2016). The lack of ICT related design thinking skills has been suggested to be one barrier to teacher's innovative ICT use (Tsai & Chai, 2012). While teachers would have the required resources to overcome first-order barriers and possess the interpersonal and intrapersonal skills to manage second-order barriers, when regarding innovative use of technologies, the third-order barriers may still stand (Koh & Chai, 2016).

Tsai and Chai (2012) name third-order barriers as most crucial task for further teacher training and development in order to further the integration of technology to education. Highly motivated teachers can be willing to overcome first-order barriers (e.g. lack of technological equipment) in their technology practices, but those who lack the motivation might not be willing to make such efforts (Ward & Parr, 2010). However, first-order barriers can be seen as what Ertmer, Ottenbreit-Leftwich, Sadik, Sendurur & Sendurur (2012) name threshold barriers that need to be overcome to make technology use possible.

> Resolving first order barriers is more than purchasing and possessing hardware and software. Schools that centralise their ICT facilities in computer laboratories may well learn that teachers are still not using them because of the clash in timetabling and tedious booking procedures. In other words, formulating procedures and creating facilitating conditions for easy and timely access are crucial for the maximisation of use and this involves careful design thinking.[3]

Furthermore, it has been suggested that comfort with computer feature may have an impact on the intent to use technology (Makki, O'Neal, Cotten & Rikard, 2018). Therefore, it is also important to take into account the human factors that play a part in supporting or hindering learning technology use in classrooms. Teachers' lack of trust in their own technological skills and other ICT related attitudes and beliefs have an impact on what and how technology is used in their classes (Goode, 2010; Makki, O'Neal, Cotten & Rikard, 2018). Therefore, understanding the factors that support or prevent teachers from using technology with their students or to support their work is further explored in this thesis.

Through increasing teacher's technology pedagogical content knowledge (TPACK) and related ICT design thinking skills, it is suggested that teacher's pedagogical flexibility may increase and they are more likely to use technology in their teaching and learning practices (Tsai & Chai, 2012). Tsai & Chai (2012) argue that the essence of TPACK model is on dynamic creation of knowledge and practice of teachers when considering pedagogical affordances, thus moving

[3] Tsai & Chai, 2012

teachers from justified beliefs towards design thinking, which as skill may enable changing current practices to make ICT integration possible. Moreover, teacher's resistance towards the implementation of a new technology is likely to rise, if implementing a new technology also requires pedagogical changes (Zhao & Cziko, 2001).

5.3 Support and training for ICT implementation

Teachers require support for implementing new digital learning solutions into their teaching and classroom practices. It requires time and effort to learn a new technology and to integrate it into teaching and learning practices (Marra, Howland, Wedman, & Diggs 2003). Vrasidas (2015) points out that preparing ICT-based activities may require more time than planning and creating traditional learning tasks. Means (2010) highlights that a large number of teachers are willing to work hard in order to integrate technology into their teaching practices only if they are certain that the technology will have a great impact in the learning outcomes of students. Means (2010) suggests that for the support of the implementation of technology guidance and support is needed in those practices that cause students to achieve better learning outcomes. The process of integrating technology into learning may require support from other actors in schools, such as principles and technological and pedagogical support personnel (Schiller, 2002; Kenttälä, Kankaanranta & Neittaanmäki, 2017). It has been indicated that there is a connection between teacher's decision to integrate ICT to their teaching and the support they receive from school management (e.g. Inan & Lowther, 2010; Kopcha, 2012).

Support for using technology can differ in the type of needed support and the way it is provided to the user. When using technology in learning and teaching in classrooms the main support types identified in research include forms such as pedagogical, technical and subject specific support (Kenttälä, Kankaanranta & Neittaanmäki, 2017). Support is also needed to build professional digital confidence that enables teachers to utilise ICT in their teaching and learning practices (Kenttälä, Kankaanranta & Neittaanmäki, 2017). When it comes to the support for the implementation, attention should not only be on acquiring the ICT skills but attention should also be paid to supporting teachers in engaging their students to learn (Yuen, Law, Wong, 2003). In many cases while bringing the new technology into schools the appeal of technology has been trusted too much with it resulting in overrating the number of teachers that are capable of utilizing the new technology in their teaching without sufficient support and guidance (Govindasamy, 2002; Roschelle, Knudsen & Hegedus, 2010). However, ICT training offered to teachers has traditionally been mainly offered as short-term courses and individual workshops and there might not be any unified or long-term training available for teachers (Harris, Mishra, & Koehler, 2009).

While professional development might be available for teachers, the offered training does not necessarily promote digitalisation of teaching and learning practices, but focuses on learning individual technologies. Professional development training focusing on digital technologies and literacies is often offered as short-term training that is workshop-based and focused around the available technologies (Curwood, 2014; Harris, Mishra & Koehler, 2009). Curwood (2014) argues that the aforementioned technology-oriented training usually only promotes the understanding of the limitations and affordances of specific tools. This type of technocentric (Papert, 1990) training neglects to address the issues of how technology can promote student-centred learning or change and enhance pedagogy (Curwood, 2014). Therefore, increasing the amount of professional development teachers receive might not promote digitalisation of education, as the training offered does not necessarily address these issues.

Furthermore, there also remain concerns about the measurements taken to understand what type of training is considered to be successful in ICT professional development. Many studies address the issue through asking participants about satisfaction with the experience and their assessment, whether the training was useful for their work after the training, but do not address the relationship of professional development, technology integration and teacher learning (Curwood, 2014; Lawless & Pellegrino, 2007). Woodrow (1992) puts teachers' attitudes towards ICT in the centre of the implementation stage of new digital technology or digital pedagogy. According to Randhawa and Hunt (1984), the use of computers in teaching is limited if teachers have negative attitudes towards them. Teacher's positive attitude towards technology plays a crucial role in increasing the use of technology in teaching. Woodrow (1992) suggests that attention should specifically be paid to ICT courses offered in teacher training in which it is possible to teach both skills and attitudes towards computers and technology.

The aim of this thesis is to understand how teachers can be supported and trained in technology use, in a way that not only provides them with the necessary technical skills, but also the flexibility, confidence and trust in their own capabilities with technology, so they can use technology with their students. The proposition in this thesis is not to integrate technology in all teaching and education, but to find ways on how to support teachers in finding a way to successfully integrate technology into their teaching and learning practices. Here professional development is considered to be key, when considering inservice-teachers' technology use. However, it is also understood that the integration of technology may in many cases require minor or major changes in the current practices of teachers. Therefore, it is also important to understand how to facilitate this type of pedagogical and attitude related change in individuals and groups.

6 VALUE CREATION IN LEARNING TECHNOLOGY

This study explores how a digital learning solution moves from being simply usable to being valuable for its user. This is accomplished by examining value creation through analysing the factors of usability and the implementation of a digital learning technology. Value is understood as the perceived value of an actor (Apilo, 2009). Value creation can be approached from several different views and from the point of view of services in business and marketing, value creation is used in connection to two phenomena (Grönroos, 2011). On the one hand, it can only refer to customer's creation of value-in-use (Grönroos, 2011). On the other hand, a broader definition, where 'the firm is not a value creator but a co-creator of value' (Lusch, Vargo, & Wessels, 2008), consists of the entire development, design, manufacturing and delivery process and other related activities and also customer's creation of value-in-use (Grönroos, 2011). In this study the broader definition is applied and value creation will be examined through analysing design and implementation of technology, focusing on user perceived value of a digital learning technology.

Rapid pace of technological advancement and the limited lifespan of devices provide challenges to teachers and schools. Firstly, there is the challenge to keep up with the changes in technologies, but yet provide and facilitate safe learning experiences and environments for students even when using digital technology (Majumdar, 2015). Secondly, a vast amount of money is used in educational technology purchases hoping it would improve student learning outcomes (Bulman & Fairlie, 2016). The economic situation of municipalities and individual schools may differ greatly and therefore not all schools are on the same level, when considering their ability to gain access to technology and digital resources (Kenttälä, Kankaanranta & Neittaanmäki, 2017). Therefore, the focus on technology purchases may not always be on their inherent value, but the added-value they bring to current practices or student learning, thus making the purchase additional ICT resources justified.

The question of added-value of technology to teaching and learning is often asked, when considering implementation of new technology as the integration of learning technology to education is in many cases still seen as a novel thing instead of being a natural part of education (Burbules, 2018; Kankaanranta & Puhakka, 2008; Kenttälä, Kankaanranta & Neittaanmäki, 2017; Tennent, Windeknecht & Kehoe, 2004). This research aims to move beyond the paradigm of technology as being something separate from teaching and the demand of added value, instead the focus is given on the factors that create value in learning software. Teaching can be and has been for centuries successfully practiced without digital technology, and simply creating technology that is seen as additional and providing additional value (e.g. student motivation) is limiting the integration of ICT as a natural part of education (Tennent, Windeknecht & Kehoe, 2004; Vrasidas). Therefore, the move towards understanding the perceived value of technology by users is required.

Furthermore, taking new technology into use may not be simple or effortless to all teachers and may cause them additional work (Govindasamy, 2002; Vrasidas, 2015). According to Govindasamy (2002), the implementation of online teaching in an organization leads frequently to the assumption that teachers and other employees in higher education should instantly be able to transform from their current roles as instructors to producers of online teaching materials. However, this role may consist of several tasks which include various skills such as content design, designing of graphic appeal and programming, that cause additional unpaid work for instructors, which in turn may increase resistance in the implementation of online teaching (Govindasamy, 2002). Therefore, understanding the role of user identified value of technology products is important to examine what are factors that make teachers to go through the extra effort and integrate ICT into their teaching (Means, 2010).

To understand value creation the viewpoint of the customer, user expressed value and perceived usefulness of learning software is necessary to understand how technology is adopted to education. Kotler (2017) points out that while in marketing it has become mantra that the marketer should create, produce and communicate customer or user value, care should be taken not to create what the marketer considers to be value, but what the customer perceives as value. The need is to distinguish between function (what the product does) and desired outcome (what users want to achieve) (Kotler, 2017). While learning technologies may be purchased by municipalities, schools or even teachers, who might not use the technology themselves for learning purposes, the value of learning technology is ultimately linked to the value it brings to learning outcomes or teaching practices (Tennent, Windeknecht & Kehoe, 2004; Zaharias and Poylymenakou, 2009).

Perceived usefulness of software has been found in multiple studies to have an impact on teacher's integration of ICT in their teaching and learning practices and intention to use technology (Scherer, Siddiq, & Teo, 2015; Siddiq, Scherer & Tondeur, 2016; Smarkola, 2008; Teo, 2009). Other factors that affect teacher's ICT integration practices include self-efficacy ICT experience and skills (Hernandez-Ramos et al., 2014; So, Choi, Lim & Xiong, 2012). Perceived usefulness has been widely researched as it has been considered to be one construct that can predict teachers' actual ICT use, which is a construct of teacher's intention to use ICT and attitude towards ICT (Chien, Wu, & Hsu, 2014; Davis, 1989; Scherer, Siddiq, & Teo, 2015; Teo, Lee Chai & Wong, 2009). Generally perceived usefulness refers to how useful teachers consider ICT to be in increasing their work performance, however, this unidimensional conceptualization has been later criticised for not taking into consideration the specific goals in teachers work performance related teaching and facilitating student learning (Niederhauser & Perkmen, 2010; Scherer, Siddiq, & Teo, 2015; Venkatesh, Morris, Davis & Davis, 2003). As Scherer Siddig and Teo (2015) point out perceived usefulness should, rather than focusing on general ICT, be a multidimensional construct, where usefulness is related to specific teaching and learning purposes.

Zaharias and Poylymenakou (2009) suggest that the usability of e-learning designs is based on their pedagogical value. In the 1990's usability research conducted on learning software commonly revealed that an application might be either technically usable, but lacking in pedagogical usability or be pedagogically well thought out, but be lacking in its technical usability or in aspects related learner engagement (Albion, 1999; Quinn, 1996; Squires & Preece, 1999). Moreover, as Quinn (2005) explains alignment of elements that create engaging experiences in e-learning games and effective learning is necessary to understand, when creating e-learning games. As learning technology designers, the focus should not only be placed on designing content, instead a shift of design perspective towards designing experiences should be made (Quinn, 2005). Deep understanding of the elements of effective learning and engaging user experiences are required to create effective learning games (Quinn, 2005). This increased engagement and increase in student motivation can be seen as perceived value for teachers, as motivation is seen as one of the value adding factors in learning technology (Kenttälä, Kankaanranta & Neittaanmäki, 2017).

7 DEVELOPING THE LEARNING TECHNOLOGY USABILITY FRAMEWORK

The development of the learning technology usability framework was conducted in three articles (PI, PII and PIII) that move step by step towards the finalised model of learning technology usability. Through this work a holistic and contextually focused framework for learning technology usability design was developed. This framework was developed to support learning technology designers in creating learning technologies that better suit the dynamic social and individual learning contexts in classrooms.

7.1 Article 1. Usability challenges in digital learning solutions

Aim
The first article PI focused on technical usability issues in learning software. The aim was to evaluate digital learning technologies to understand the amount and severity of usability problems in the learning technologies available and used by teachers. Additionally, some preliminary comparisons between learning technologies from three countries or country groups (Finland, Spanish speaking countries and Asian countries) and the types of learning technologies (content solutions and tools and platforms) were made.

Method
In PI heuristic evaluations (Nielsen, 1995) were conducted individually by two researchers on the user interfaces of 24 learning software from Finland, Spanish speaking countries and Asian countries. The data from individual evaluators was compared and combined to create the final evaluation.

Results and contribution to the whole
The main results of PI confirm the observation made in previous research that a few heuristics cover the majority of all usability problems (Granić & Ćukušić, 2011;

Nielsen, 1994a). However, the heuristics with highest number of observations also contained a relatively low proportion of usability problems that were considered to be severe and more than half were rated as minor usability problems. Even though there was a high number of observations in heuristics such as 'consistency and standards' these problems might not be severe usability issues that would prevent using the learning software. When considering the severity ratings of the usability problems there were two heuristics that contained more than half of all usability problems rated as major issues. The two heuristics were 'error prevention' and 'helping users recognize, diagnose, and recover from errors', which both deal with errors or recovering from errors. This finding is in line with previous research that suggests that there is a difference between the severity ratings in individual heuristics (e.g. Nielsen, 1994a; Zaharias & Koutsabasis, 2011). The heuristics that deal with error situations and recovery from those situations are to prevent or hinder the use of the software or some feature of it.

In this preliminary work this larger context of the work related to learning software evaluations taken in the project was not taken into account and the focus was solely on technical usability. As an initial first step towards understanding the complexities of learning technology usability focusing firstly on the narrower technological view of usability was valuable. This view was then broadened in the following framework development work presented in PII and PIII.

Author's contribution

As the corresponding author I was responsible of the overall writing process and the analysis presented in the article. The co-authors provided their expertise in reviewing and structuring of the paper, as well as commenting and contributing their expert views on my analysis.

7.2 Article 2. Towards the Learning Technology Usability framework

Aim

The aim of the second article PII was to create a preliminary Learning Technology Usability (LETUS) framework for designing usable learning technologies. The framework was developed to aid the design of technologies that can be used for learning purposes without technical barriers hindering the learning experience.

Method

The data for PII was collected as a part of the international expert evaluations of learning technologies (see Mäkelä, 2015). The data consisted of 113 evaluations from 7 countries assessing the design of the evaluated learning technologies. This open-ended questionnaire data was coded by two researchers and later checked for reliability through researcher triangulation. Through this work a unified coding framework was created. This coding framework was then in PII combined with the analysis of 13 usability design and evaluation frameworks. Through the combination of these two data sets the preliminary Learning Experience Technology Usability framework was created.

Results and contribution to the whole

The main result of PII was the initial Learning Experience Technology Usability (LETUS) framework is work that aids the design and evaluation of digital learning technologies. The framework consisting of four components: Learning, Content, Technology and Context (Table 3). This preliminary framework was the first attempt to create an efficient framework for evaluating learning technologies that aim to create meaningful learning experiences.

TABLE 3 Learning Experience Technology Usability -framework components

Learning	**Content**	**Technology**	**Context**
Feedback Guidance and instructions Concentration and attention Collaboration Assessment Confidence Motivation Skill development Previous knowledge Differentiation Skills for learning Creativity	Goals Authenticity and relevance Readability and literacy Concepts Multimedia	Flexibility Control Errors Consistency Aesthetics and trust Navigation and intuitiveness Communication Interaction Accessibility Scalability Reliability and maintainability	Satisfaction Immersion and flow Applicability Added value Sociocultural relevance

This work conducted in PII contributed to furthering the understanding of the complex nature of learning technology design and the factors that affect digital learning technology usability. This framework contributed into building a solid foundation for creating the finished LETUS Design framework presented in PIII.

Author's contribution

As the corresponding author I was responsible of the overall writing process and the analysis presented in the article. The co-authors provided their expertise in reviewing and structuring of the paper, as well as commenting and contributing their expert views on my analysis.

7.3 Article 3. Learning Experience Technology Usability Design framework

Aim

The aim of this study is to reiterate and fortify the Learning Technology Usability (LETUS) framework (see PII) to provide a holistic and efficient framework for designing and evaluating learning technology. This work expands on the LETUS framework, but focuses especially on furthering the understanding of contextual aspects that affect learning technology use to aid the creation of learning technology with high contextual suitability.

Method

In PIII the framework created in PII was further elaborated through content analysis of practice-based articles on technological pedagogical content knowledge (TPACK). This was done to fortify the contextual aspects of the LETUS framework to create the finalized LETUS Design framework. The data consisted of 14 TPACK articles chosen based on Rosenberg and Koehler's (2015) critical analysis. The text in the articles focusing on context was coded and these categories were used to reiterate the categories in the LETUS framework.

Results and contribution to the whole

The third article (PIII) delved more deeply into the design aspects related to creating both usable and valuable digital learning software that both teachers and learners alike can benefit from. At this stage the framework created in PII was complemented and expanded by relating the contextual aspects of the TPACK-model (Koehler & Mishra, 2009) to the framework. Altogether 14 articles, where the contextual aspect of the TPACK-model was discussed in detail were analysed to further understand educational context. Based on this work the framework was redesigned to better accommodate the complex contextual needs educational use places on technology.

Context was repositioned as being an overarching part of the three other components (Learning, Content and Technology). Furthermore, based on the analysis it was understood that context also consisted of three levels of context: *micro, meso* and *macro*.

- *Micro context* included the factors that are immediate in the ICT use context in classrooms.
- *Meso context* consists of the previous knowledge and factors not immediately related to or stemming from the use situation, but that can influence it such as teacher's pedagogical choices.
- *Macro context* takes into consideration the systemic conditions created by for example curriculum and teacher training.

The previously four component model (Table 3) was regrouped (Figure 3) based on the contextualisation analysis to further explain how context affects all the other components of the framework.

FIGURE 3 The Learning Technology Usability design -framework

This work concludes the usability design portion of this work and contributes to building the From Design to Use -model (Chapter 9) by discovering the usability factors that affect the contextual usability of learning technologies. Through this work the technological barriers and design of technology that has value to its user is finished.

Author's contribution

As the corresponding author I was responsible of the overall writing process and the analysis presented in the article. The co-authors provided their expertise in reviewing and structuring of the paper, as well as commenting and contributing their expert views on my analysis.

8 SUPPORTING TEACHERS ICT INTEGRATION

Simply introducing new technologies to teachers and students is not enough to ensure the meaningful and efficient use of technology in class. The use of technology in education has been shown to cause stress (technostress) to teacher's technology fatigue and technostress have been researched and it has been understood that one reason that causes technostress to teachers is the lack of usability in technology (Al-Fudail & Mellar, 2008).

8.1 Article 4. Courage to learn and utilize ICT in teaching - building understanding of teachers who lack courage

Aim
This paper aims to shed light on those teachers who lack the necessary courage to try new (ICT related) approaches. The paper attempts to find out, what are the qualities and skills of those teachers who are not yet flexible and courageous experimenters in using ICT in their teaching. Thus, the paper aims at building understanding of such teachers' current ICT-related teaching practices and skills as well as their needs for professional development. By doing this, we try to find more beneficial approaches towards closing the ICT related practice gap among teachers.

Method
The data was collected through an online survey. Survey respondents included 151 in-service teachers from school levels ranging from preschool to upper secondary school in Central Finland (Kenttälä, Kankaanranta & Neittaanmäki, 2017). When addressing the issue of ICT use barriers for teachers, one interesting observation is related to teachers' self-belief of their courage to use new ICT related approaches alone. Out of 151 teachers participating in the ICT survey 74 % assessed that they have courage to try new approaches alone. However, 26 % indicated that they didn't have enough courage. This paper focuses on this 26 % and aims to map out whether these teachers share other qualities and what are the issues related to the ICT related support they receive.

The main focus is on building understanding of the shared and individual characteristic of the teachers who indicate they lack courage in implementing new approaches. Some preliminary comparisons will be made with the group of teachers, who indicate they have courage to try new ICT approaches.

Results and contribution to the whole

The fourth article PIV analysed and discussed the human elements (second-order barriers) that affect learning technology implementation in educational and classroom context. The result of PIV suggest that the group of teachers lacking courage to try new approaches alone shared a more negative outlook on their ability to manage more complex tasks with ICT, than teachers who said they have courage to try new ICT approaches alone. However, it was also observed that mobile technologies may provide teachers lacking courage more pedagogical affordances than computers and thus motivate their creativity and design thinking skills.

The work in PIV contributed to understanding the second-order barriers to ICT integration through analysis of the teachers lacking courage to try new approaches. Through this work the understanding of how to support teachers in ICT integration was furthered. The article builds on the implementation and use portion of the From Design to Use -model by creating understanding of the factors that may prevent teachers, who self-identify not having courage to try new approaches alone and how they could be supported in ICT integration.

Author's contribution

As the corresponding author I was responsible of the overall writing process and the analysis presented in the article. The co-author provided their expertise in reviewing and structuring of the paper, as well as commenting and contributing their expert views on my analysis.

8.2 Article 5. Building ground for flexible use of educational technology

Aim

The aim of PV is to analyse the barriers to ICT integration in schools and how overcoming these barriers is supported in schools. For this study teachers were divided into two subgroups based on their self-assessed possession of pedagogical ICT skills. Based on previous research on second- and third-order technology integration barriers this study investigates, whether teachers, who have pedagogical ICT skills, express fewer barriers to ICT integration than teachers, who lack pedagogical ICT skills.

Through the analysis of principal and teacher questionnaire data, this article examines two research questions:

1. What are the barriers to ICT integration in schools?
2. How integration of ICT to teaching and learning practices is currently supported in schools?

Method

The data in PV consists of quantitative and qualitative data from complimentary online surveys for principals and teachers (Kenttälä, Kankaanranta & Neittaanmäki, 2017). The online surveys for teachers and principals consisted of both questions that were common to both groups and questions that were unique to each group. Teachers were asked about their own daily practices with pupil's and principals answered questions related to school level ICT use in their school. Therefore these two data sets were not compared to each other in this study. The data in this study consists of responses from 39 principals and 111 teachers from 39 schools. Teacher responses are further divided into two subgroups: teachers who require training pedagogical ICT use (n = 39) and those who do not (n =72).

Results and contribution to the whole

The results of PV focused on four categories: 'ICT use in schools and actions to support ICT integration', 'Professional development offered and needed', 'Barriers to ICT use' and 'Current ICT practices'. The results suggest that all three levels of barriers (first-, second- and third-order) can be observed among teachers from both subgroups. Thus suggesting that, while there still remain technology related barriers (e.g. lack of access, time or equipment) in many schools, there are also other human or design thinking related barriers that need to be addressed to enable ICT use in schools. One way of addressing second- and third order barriers, is providing relevant professional development opportunities to teachers.

Principals in general shared a negative outlook on teachers' current technical ICT skills and indicated the need for improving teachers overall technological and pedagogical ICT skills. Furthermore they indicated that there were many types of professional development available for the teachers of their schools. However the types of training principals said were offered did not on all accounts match, with those teachers expressed the desire to participate on. Moreover, teachers viewed that they did not have the opportunity to participate in professional development that they would require in order to be able to integrate ICT in to their teaching. Thus indicating that, while professional development may be available, it might not be accessible or relevant for those teachers, who require additional training.

The results of this study affirm the knowledge from previous research that even though technology may pose limitations to teacher's technology use there are teachers, who are willing to overcome these barriers. However, teachers self-identified possession or lack of pedagogical ICT skills did not necessarily reflect on how they used technology with their students. This might suggest that not all pedagogical affordances of technology are necessarily identified by teachers, even though they assess they have pedagogical skills to use ICT.

Author's contribution

As the corresponding author I was responsible of the overall writing of the manuscript and the analysis presented in the article. The co-author provided her expertise in reviewing and structuring of the paper, as well as commenting and contributing her views on my initial analysis.

9 DISCUSSION

The aim of this study was to create understanding of the factors that can help moving learning technologies from being usable to being valuable to teachers. This was done through a two-part process including usability design and use of learning technologies. In this work a theoretical model for addressing and overcoming the known obstacles of ICT integration and providing teachers with technology that is valuable part of teaching and learning was created. This was accomplished through addressing two research questions:

1. What factors influence the usability of digital learning technologies?
2. What factors support or hinder the implementation of learning technologies in classroom teaching?

Firstly, the factors that influence the usability of digital learning solution were analysed and researched by the means of heuristic evaluations and later on through analysis of expert evaluation data and relevant research articles. There are several factors that can influence the usability of a digital learning technology as the educational context poses many challenges. The main results of this research place emphasis on the highly contextual nature of usability and suggest three contextualised categories of factors that should be considered, when developing and evaluating learning software usability: learning, technology and content.

Contextually it was understood that the factors influencing usability of a particular learning technology are apparent on three contextual levels: micro, meso and macro. Micro level being the most immediate and use situation-oriented factors, meso level being more intra- and interpersonal factors and macro level being local community and society level of factors. Through this categorisation the knowledge of barriers of implementation of learning technologies were also furthered as the role of teachers' and students' personal beliefs and attitudes towards technology were seen to have an impact on the contextually relevant usability of learning solution. Furthermore, this overlapping also fortified the overall purpose of this study in finding a model that could be utilised to bridge the gap from design of a learning solution into implementation and use of the learning solution.

Secondly the factors that support of hinder the implementation of learning solutions in classroom teaching were analysed. When looking at the implementation of learning technologies there are several identified barriers and this work approached the question through creating understanding of courage to try new technology related practices and flexibility in technology use. The main results of articles PIV and PV provide understanding of the barriers in teacher's ICT integration and suggest that further training and support is required to support teachers in overcoming the barriers of ICT integration. The barriers include all three levels of barriers (first-, second- and third-order barriers), out of which special emphasis was given to second- and third order barriers.

This thesis focused on the themes of courage and flexibility, which could in turn enable teachers who are currently doubtful or hesitant about technology integration to take first steps towards including ICT into their teaching. Furthermore, it was suggested by PV that more knowledge is required to understand what the pedagogical views teachers associate with ICT use are and what kind of training could spark their design thinking skills to enable them to create versatile ICT learning activities for their students.

9.1 From Design to Use

The theoretical model presented in this study was created through iterative design. In the early stages of research a preliminary framework was drawn based on the early ideas of, what could be the relevant factors to be covered when approaching value creation in learning technology (Figure 4). This preliminary framework acted as the starting point to the research and was later modified as the understanding of the field grew through research. In the preliminary framework value creation is seen as the combination of usability factors and mainly support form related factors that would be analysed in this dissertation. Thus, creating the basis for the overall two-part structure of this dissertation and articles presented in this study.

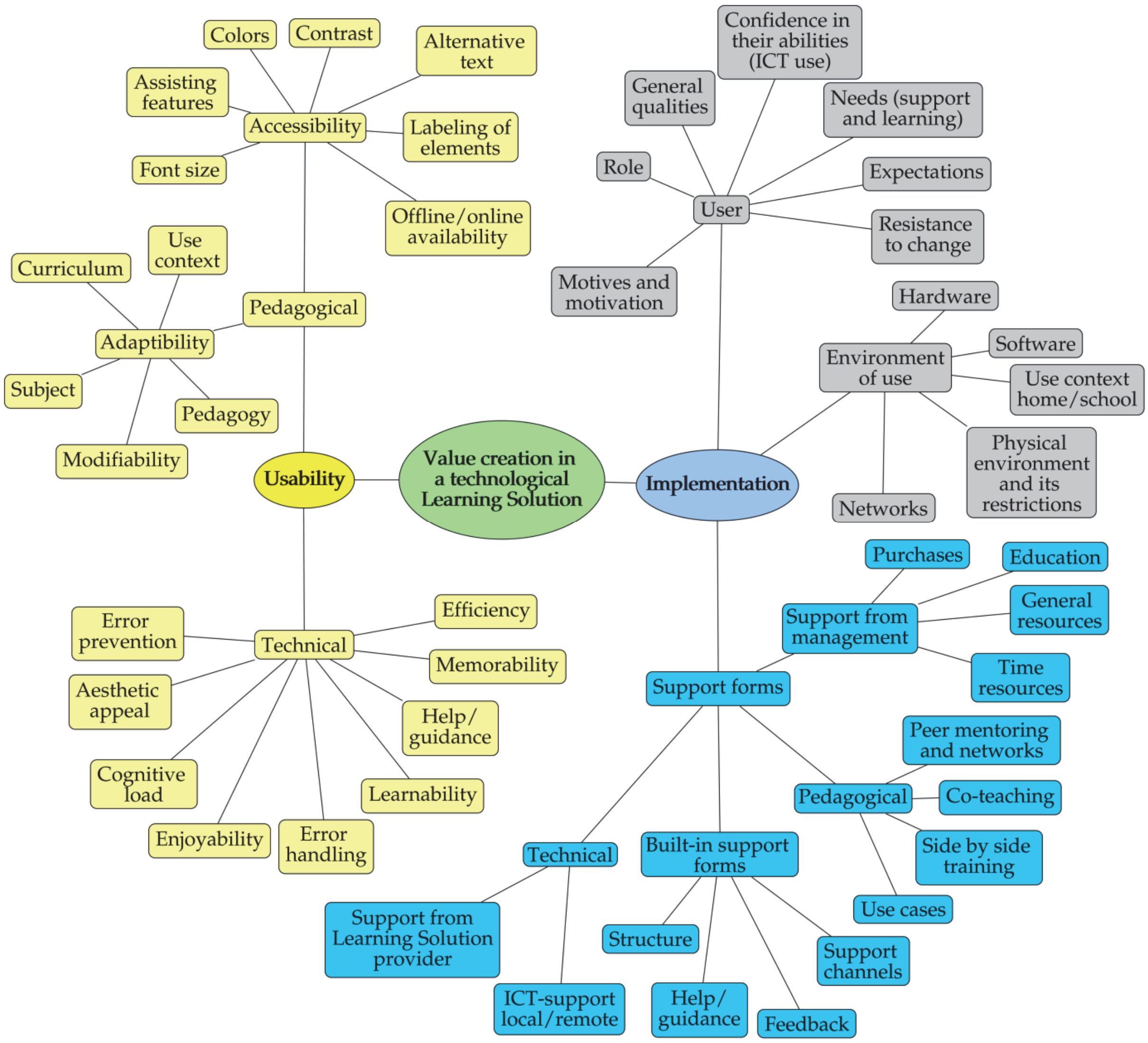

FIGURE 4 Preliminary version of the value creation framework

Firstly, this initial overall framework proved to be an oversimplification of the factors related to the design of learning technology, which supported the artificial division between technological and pedagogical usability based on previous research. Secondly, some areas of the framework (e.g. accessibility) are on a too detailed and specific level for the framework, even though important details to take into account when designing accessible software. Similarly some factors were not yet understood as important factors in the design of learning technologies. These factors were listed only under the implementation of learning technologies, as contextual knowledge was accumulated through the iterative research on the topic. In later iterations of the framework it became evident that users and human related factors relevant to ICT integration would need to be researched further as previous research (e.g. Ertmer, 1999; Tsai & Chai, 2012), showed these factors playing important role in teacher ICT use. In the preliminary framework (Figure 4) the importance of barriers to technology integration was not yet understood. Also, the role of professional development in building inservice-teachers ICT competence, courage and flexibility in ICT use were not understood as they currently are.

Technology integration in education is a complex interplay between technological, pedagogical and human elements. The stage model for overcoming of barriers to ICT use (Figure 5) presented an important insight to the development of the finished model. Through researching the identified barriers to ICT integration in education, it was understood that simply covering the technological and pedagogical usability design aspects, would not necessarily suffice in ensuring that technologies move from design to use. As can be seen in the stage model of overcoming ICT integration barriers (Figure 5), which has been developed based on the research on technology use barriers (e.g. Ertmeer, 1999; Tsai & Chai, 2012), there are three barriers that need to addressed before technology can be seen as being an integrated part of teaching and learning practices. In the first stage technology is not used or it is not accessible to users. This leads to the first-order barriers, which can be overcome by providing access to relevant technology and technical skill to use ICT. At this stage technology use is possible, but not necessarily meaningful to learning. Furthermore simply crossing the technological use barrier does not ensure that teachers use the technology in classroom teaching (Brás, Miranda & Marôco, 2014).

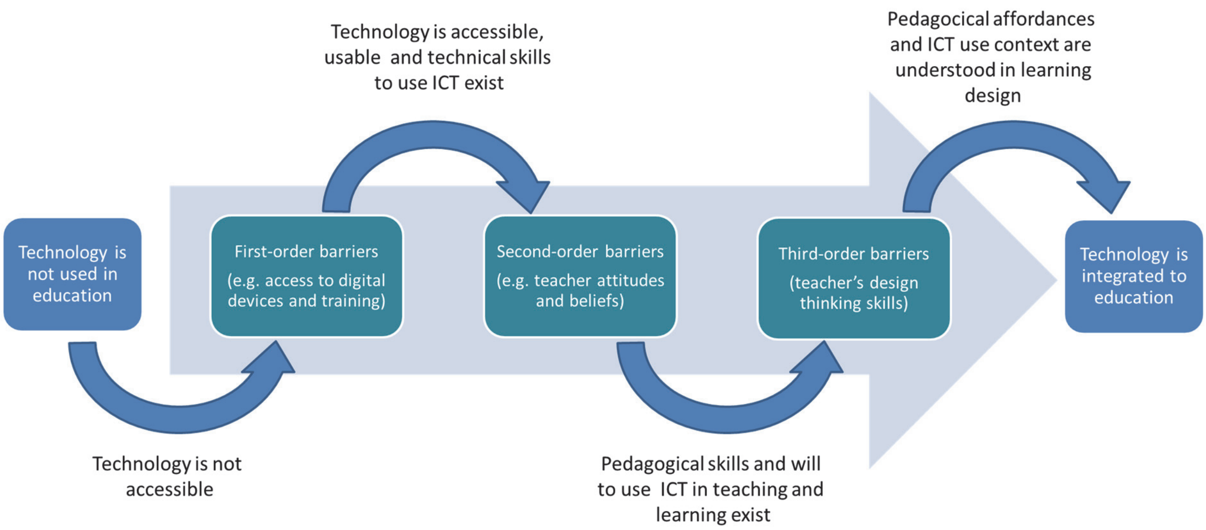

FIGURE 5 Stages of overcoming barriers to ICT integration in schools

After crossing the first-order barriers there still remain two levels of barriers: second-order and third-order barriers that need to be overcome. Second-order barriers to technology integration consist of human related barriers (Tsai & Chai, 2012). Overcoming these barriers require the training of pedagogical skills to use ICT in teaching and learning, but also the will to use ICT in teaching and learning needs to exist within the teacher. This observation is also supported by the will, skill and tool -model, which indicates that to able to effectively integrate technology into education teachers need positive attitudes, technology competency (technical and pedagogical use) and access to technology tools (Agyei & Voogt, 2011). However, as Tsai and Chai (2012) have pointed out a third kind of barrier to technology integration also exists. These third-order barriers are related to teacher's design thinking skills. The complexity of the use context and its dynamic nature pose a challenge to teachers. Supporting teacher's design thinking skills requires developing their understanding of the affordances of technology and also the use context. Through developing flexible design thinking skills in teachers to overcome the third-order barriers would provide a solid basis for integrating technology as a natural part of classroom learning and teaching practices. Therefore this thesis suggests that teachers require systematic and incremental training to be able to overcome all three levels of barriers and efficiently integrate ICT to education.

This work was developed through the work conducted in the articles (PI, PII, PIII, PIV and PV) presented in this dissertation. The usability design side of the model (Figure 1) was developed through the initial technical usability assessments in PI, which addresses the technological barriers to technology use. The research knowledge gained from this paper was then applied in the development of the preliminary usability model presented in PII. The model presented in PII, while was still, however, lacking in the educational context specific factors. This finished theoretical LETUS-framework was presented in PIII, where the work conducted in PII had been further enhanced through careful and critical analysis of research on the widely used TPACK-model.

However, as has already been discussed in the introduction of this thesis simply increasing access to technology does not necessarily result in their integration into teaching and learning practices. Therefore, in this dissertation the design framework for creating contextually suitable and usable educational software was supported by also moving into the use of ICT in education. This work was conducted in articles PIV and PV. As the implementation and use of ICT is a vast field with several factors, in this research the focus was on teacher's lack of confidence and lack of support. Lack of confidence was explored in PIV through teachers, who expressed they did not have enough courage to try new approaches alone. Their feeling of not having enough support was also addressed. This work was then complimented by giving more focus on the support and training offered for teachers to overcome ICT integration barriers and what type of professional development they would still require in PV.

When combining the knowledge gained through the research presented in Chapter 7, designing usable learning software, and Chapter 8, supporting users in ICT integration, the finalized From Design to Use was developed. Figure 6 introduces the From Design to Use framework that has been created based on previous research and the research in the articles presented in this dissertation. The model suggests that there are various steps that need to be taken in order to enable all teachers to integrate ICT as a valuable part of their teaching.

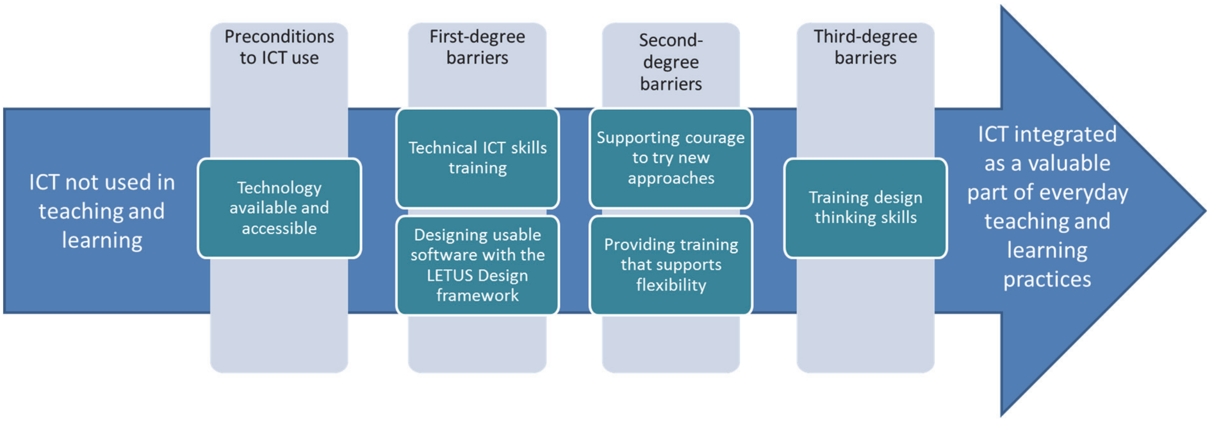

FIGURE 6 From Design to Use -model of crossing ICT integration barriers

In this work the proposition of bringing value to teachers through understanding factors of usability and implementation is based on the idea of freeing teacher's capacity to see the affordances and possibilities that technology can bring. Through creating technology that is contextually suitable and making the implementation of learning software less stressful and daunting through supporting teacher's courage and design thinking, the aim is to remove barriers from seeing the value that integration of technology can bring to education. Firstly, by ensuring that technologically, pedagogically and content wise the technology matches the current dynamic educational contexts needs resources can be freed from learning the technology and tackling usability problems to using the software for teaching and / or learning. Secondly through understanding that implementation of technology in schools takes place in a dynamic social environment, supporting teachers requires more than simply teaching them technical or pedagogical ICT skills to match the learning software. Therefore, the proposition is to support teacher's retention of full emotional and creative capacity, through design thinking training also to enable making more informed decisions about technology use.

9.2 Trustworthiness of the research

When conducting mixed methods research, the relevant characteristics of both quantitative and qualitative methods need to be considered (Johnson and Onwuegbuzie, 2004). The trustworthiness of qualitative research can be assessed using the four criteria: transferability, credibility, dependability, and confirmability (Cuba, 1981; Lincoln and Guba, 1985). The criteria for assessing the trustworthiness of quantitative methods are: internal validity, external validity, reliability and objectivity (Teddlie & Tashakkori, 2009). Furthermore, as the research utilises qualitative dominant mixed methods approach these two criteria will be discussed together combining the terms from each tradition that are analogous: credibility (internal validity), transferability (external validity), dependability (reliability) and confirmability (objectivity). In the following section the actions to ensure the trustworthiness of this research are discussed in terms how they meet the criteria for trustworthiness.

Credibility, which in quantitative research is analogous to the term internal validity, considers the confidence in the "truth" of the research that entails questioning whether the phenomena set out to research was actually examined. In this research the aim was to examine 'how learning technologies can move from being usable to being valuable to their users". To enhance credibility triangulation of different data was used and also examiner triangulation was utilised. As this research utilises several sets of data (heuristic evaluations, expert evaluation and survey data) to examine the different sides of the phenomena, to gain a holistic picture of the whole phenomena, different actions were performed for each set of data. Firstly, data triangulation was used in PII and PIII to create coherent categories for the design framework. Similarly, in PIV, PV and the From Design to Use model presented in the compilation part, data triangulation was used to complement and enrich the data in order to get a fuller understanding of technology use barriers for teachers. Secondly in PI examiner triangulation (Guion, Diehl & McDonald, 2013) was used to ensure the accuracy of the evaluations and severity ratings. In all articles the work was thoroughly checked by co-authors and reiterated to ensure accuracy of the analysis.

Transferability, in quantitative research external validity, focuses on the extent that the findings of the study can be applied in other contexts and situation (Lincoln and Guba, 1985; Teddlie and Tashakkori, 2009). Broad generalisations would require a large sample population, which was not the case in this research. However, as the main emphasis is on qualitative methods, the sampling in this research adheres to the qualitative tradition where sample selection is typically small, non-random, and purposeful (Villar, 2008). In the use portion (PIV and PV) of the research survey data was collected in the Central Finland region, thus meaning that the variables could be specific to Central Finland area and Finnish culture. However, to increase the transferability of the results a representative sample of schools in Central Finland was selected as the sampling strategy for data collection in PIV and PV. Also, the selection of learning technologies to be examined (PI and PII) was geographically and otherwise limited to only certain regions (Finland, Spanish speaking countries and Asian countries). Lastly in PIII the selection of TPACK as the theoretical framework for understanding educational context, might have limited the transferability of the results. To increase and ensure transferability thick description (Lincoln & Cuba, 1985) was used to provide enough detail of the context to aid researchers in making comparisons with their research contexts (Shenton, 2004). As the data in this thesis consists of qualitative case study data the intention was not to generate broad generalisations, but to create a baseline for understanding the phenomenon. Transferability in all articles and the compilation part was increased through analysis of other relevant theories and research in the relevant fields.

Dependability, analogous to reliability in quantitative tradition, refers to repeatability of the research procedures. This means that in quantitative research when research procedures are conducted in the same context, with same methods and participant, they would produce similar results (Guba & Lincoln, 1985; Guba & Lincoln, 1994). Articles PI, PII, PIII and PV were fully or partially qualitative and the data analysis utilised content analysis as a method. In content analysis the categories are derived from data and to ensure the dependability it is important to develop a systematic and logical coding scheme (Hsieh & Shannon, 2005). In each article utilising content analysis the categories were developed in discussion with the co-authors and reiterated based on the consensus among the co-authors about the categories. This process was conducted as face-to-face discussions supported by online communication to ensure the dependability of the coding schemes and analysis in all stages of the research.

Confirmability, in quantitative tradition analogous to objectivity, refers to the aim that the use of research instruments is not relying on skills and perceptions of humans (Shenton, 2004). In order to ensure confirmability triangulation and multiple research methods were used, including surveys and evaluation forms with multiple scales (nominal and open-ended). The design of the instruments used in PII, PIV and PV were conducted by a group of researchers and utilised already existing large-scale surveys as the starting point for instrument design. However, as the instruments nevertheless were designed by researchers, the influence of researcher bias cannot be avoided (Patton, 2002). As Miles and Huberman (1984) suggest it is important to identify and admit these predispositions of researchers. These biases have been acknowledged in the reporting of the research. As Villar (2008) suggests, biases can also emerge from the factors in the instrument having an impact on the responses. This bias has been acknowledged in the articles and analysis of the data.

In conclusion various strategies to ensure the trustworthiness of this research were employed. Nevertheless, the subjectivity of the researcher was an undeniable part of the research. However, all decisions and approaches utilised in this thesis are justified and the biases identified are acknowledged. Therefore, the research presented in this thesis can be considered trustworthy.

9.3 Conclusions and further research

This thesis addresses the issue of ICT integration into education through considering usability design and actualised ICT use the all-important joint-phase between designing valuable learning technology, making it an integral and valuable part of the everyday practices of teachers. This contribution brings further understanding on the current barriers and challenges teachers and learning software developers face, and it brings understanding on how to cross these barriers and make ICT integration into a possibility of the near future. Even though advancements have been made to overcome the barriers to ICT integration, they still remain in many schools and technology integration has not been achieved (Kenttälä, Kankaanranta & Neittaanmäki, 2017; Vrasidas, 2015). However, positive outcomes towards ICT integration have been achieved through project-based development work, however, only some project-based implementations of technologies lead to sustained practices (Ertmer and Ottenbreit-Leftwich 2010; Jordan, 2018; Sandholtz and Ringstaff 1996).

There are several interesting research directions that can expand the research presented in this thesis. Firstly, the need to test the theoretical From Design to Use model in practice from early design stages to the use of the finished product still remains. Furthermore, also validation of the Learning Technology Usability –framework in evaluation and design of learning technologies can be considered a future challenge. Research instruments and practical tools through which the theoretical framework can be applied by designers and researchers have not yet been created and would benefit the future application of the framework. Furthermore, the contextual aspects of this framework would need to be tested in various contexts to further understand what are the factors relevant in different context, as the model provides an overall view of all contextual aspects they are not necessarily applicable in all formal learning contexts and all learning software.

Secondly the understanding of the complex interplay of value creation and user factors (e.g. attitudes and beliefs) provides interesting future research challenges. Teacher attitudes and beliefs have been identified to have an important role in supporting or hindering ICT integration (Ertmer, 2005; Ertmer & Ottenbreit-Leftwich 2010; Tsai & Chai, 2012), therefore the support aspect of this research focuses on teachers. The focus of this research was on understanding the current barriers of technology use and not on examining or testing what types of interventions would provide teachers the necessary skills and confidence to use ICT in education. Therefore, the viewpoint provided by this research acknowledges the current situation and builds theoretical understanding of how the situation could be remedied. The efforts to provide all teachers with the necessary skills to form informed opinions and make choices based on the best available knowledge about integrating technology to teaching and learning still continues.

Creation of technological applications to assess the digital capability and readiness of schools and teachers (e.g. EU Commission Joint Research Centre's SELFIE-tool) may be one way to support a more organised digitalisation of education. SELFIE, OPEKA and other similar digital tools available for schools to evaluate and improve their digital readiness and capabilities offer one of systematically supporting digitalisation (Kullaslahti, Ruhalahti & Brauer, 2019; Tanhua-Piiroinen & Viteli, 2017; Viteli, 2013). Digital change in institution level requires leadership and strategical support to be approachable by teachers (Vrasidas, 2015). To teachers similar self-assessment tools may offer the knowledge about the current state of their digital skills and at best such tools could both fortify the understanding of already attained digital capabilities and trust in their own skills, but also show in a tangible and approachable way what are the areas, where skills and knowledge need to be developed (Ossiannilsson, 2018). However, even with the digital readiness or capability measuring tools available, barriers to ICT use may still continue to exist, if resources remain to be scarce.

Even when the value of technology use in education is understood and communicated, the lack of equipment, time and training to utilise ICT in education may hinder teacher's possibilities to integrate ICT into their teaching (Drossel, Eickelmann & Gerick, 2017). Similarly, the concerns of the diminishing number of children's physical activity and growing screen-time, pose different types of challenges for teachers, when considering educational technology use (Lauricella, Wartella & Rideout, 2015; Straker, Zabatiero, Danby, Thorpe & Edwards, 2018). However, as mobile technologies and online services have become an undeniable part of everyday life of students and teachers alike, the need for teaching and learning about and with technology is also rising. One concrete way how digital technologies challenge education in Finland is the digitalisation of the matriculation examination, which also places pressure to ensure that all students have the necessary ICT skills to participate in the digital test (Kaarakainen, Kaarakainen & Kivinen, 2018; Tani, Cantell & Hilander, 2018). While screen-time and the related health concerns are important questions that require consideration and research, the need for equipping students with the skills they need to cope in the digitalising society is also important.

In providing students with these skills teachers are in a key position, but as was also seen in this thesis many teachers and schools are still unprepared and overwhelmed by digitalisation of education. Reaching a large-scale integration of ICT into education also requires systematic and systemic changes that provide the conditions, where this change can take place (Vrasidas, 2015). In this work allocation of necessary resources provides an all-important platform where the change can take place, but addition of resources alone does not necessarily promote the change (Liu & Pange, 2015). Broader discussion about the digitalisation of education needs to be opened in a way that also allows those with limited knowledge about technology be a part of the change and voice their concerns (Nardi & O'Day, 1999; Stieler-Hunt & Jones, 2017). This is important, since as was shown in this thesis implementation of technology to education takes place in a dynamic social environment, which challenges teachers' pedagogical and communicational skills, but also their design thinking skills.

Creation of ICT activities that are student-oriented and engage them in learning is complex task that requires flexibility from the teacher. This flexibility in teachers can be promoted as was indicated by this thesis through supporting their: courage to try new ICT approaches alone, understanding of technology and the skills required, and the skills to design student-oriented learning activities also when using ICT. As was discussed in Chapter 1 classroom use of ICT in some situations may lead to teachers using more antiquated pedagogy than they would utilise in their non-ICT using teaching practices. To address and prevent this shift of pedagogy teacher's familiarity and comfort with using ICT needs to be addressed through training and support that enables teachers to understand the value of learning technology to their work and their students learning. However, the change towards understanding the inherent value of ICT use in education instead of discussing ICT use as something that creates added-value may still require a lot of work. In this work both the creation of more contextually suitable learning technologies and supporting users in overcoming the barriers to ICT use is important.

YHTEENVETO (FINNISH SUMMARY)

Teknologian integrointi luonnolliseksi osaksi opetuksen ja oppimisen käytänteitä on haastava yhtälö, joka asettaa haasteita sekä teknologian suunnittelijoille että käyttäjille, mutta myös systeemitasolla. Teknologian integraation asettamiin systeemitason haasteisiin on pyritty vastaamaan mm. Euroopan Unionin tasolla annetuilla linjauksilla, joiden fokus on vuosien varrella siirtynyt teknologian määrän lisäämisestä opettajien ja oppilaiden digitaalisen kyvykkyyden kehittämiseen (Conrads, Rasmussen, Winters, Geniert & Langer, 2017). Yleisistä linjauksista huolimatta voidaan havaita, että teknologia ei ole vielä vakiinnuttanut asemaansa luokkahuoneissa, vaan sen käyttöön liittyy yhä epävarmuutta sekä erilaisia esteitä. Teknologian käytön esteiden tutkimuksessa on tunnistettu kolmen tasoisia esteitä: teknologian saavuttavuuden ja sen teknisen käytön esteet, pedagogiset ja ihmistason esteet, kuten asenteet ja uskomukset, sekä suunnitteluajattelun esteet. Tässä työssä tarkastellaan näitä esteitä oppimisteknologian käytettävyyssuunnittelun ja käyttöönoton tuen tekijöiden kautta sekä pyritään kehittämään malli näiden esteiden ylittämiseen.

Oppimisteknologioita on suunniteltu ja kehitetty opetuksen ja oppimisen tarpeisiin jo useiden vuosikymmenien ajan. Yleisen tarjonnan määrästä ja positiivisesta teknologiakehityksestä huolimatta, voidaan havaita, että monet opetukseen ja oppimiseen suunnitelluista teknologioista voivat yhä edelleen olla heikosti yhteensopivia nykyisin käytössä olevien opetusmenetelmien ja opetussuunnitelman tavoitteiden kanssa. Samoin esimerkiksi materiaalien muokattavuus voi olla tarkoitettuun käyttökontekstiin ja käyttäjien tarpeisiin nähden vähäistä, mikä voi rajoittaa teknologioiden opetus- ja oppimiskäytön potentiaalia. Näiden tunnistettujen haasteiden ratkaisemiseksi tässä työssä esitellään oppimisteknologian käytettävyyssuunnittelun viitekehys (LETUS Design -framework, ks. PIII), joka on teknologian, oppimisen ja sisältösuunnittelun sekä käyttökontekstin tarpeet huomioiva kokonaissuunnittelumalli oppimisteknologian käytettävyyssuunnittelun tarpeisiin. Tämä viitekehys tarjoaa tutkimuslähtöisen kehikon, jota soveltamalla voidaan suunnitella oppimisen ja opetuksen kontekstiin paremmin soveltuvia teknologisia ratkaisuja. Vaikka kaikkia teknologian käytettävyysongelmia ei huolellisellakaan suunnittelulla kenties voida kokonaan poistaa, voidaan merkittävät opetuskäytön esteet havaita ja korjata tehokkaimmin jo varhaisissa suunnittelun vaiheissa. Näin ollen on tärkeää lisätä opetusteknologioiden kehittäjien ymmärrystä siitä kompleksisesta vuorovaikutuksellisesta kontekstista, jossa opetus ja oppiminen tapahtuvat.

Kuitenkaan pelkkä kontekstiin soveltuviksi suunniteltujen ja käytettävyydeltään laadukkaiden oppimisteknologioiden kehittäminen ei riitä välttämättä takaamaan, että nämä teknologiat päätyvät opetus- ja oppimiskäyttöön. Oppimisen kannalta hyödylliset uudet innovaatiot voivat jäädä käyttämättä, mikäli niille ei nähdä tarvetta, joka ylittäisi käytön opettelusta koetun vaivan. Teknologian käytön opettelu ei ole ainoastaan teknisten taitojen opettelua, vaan opettajan ottaessa käyttöön uutta teknologiaa opetuksessaan voidaan havaita useita yksilötason haasteita teknologian käytölle. Viime vuosikymmeninä on nähty paljon rohkaisevia tarinoita siitä, miten opettajat omaksuvat ja luovasti hyödyntävät teknologiaa omassa opetuksessaan oppilaiden oppimisen mahdollistamiseen. Nämä tarinat voivat kuitenkin tuntua monista opettajista vieraannuttavilta, mikäli luottamus omiin taitoihin tai tiedollinen tai taidollinen osaaminen rajoittavat mahdollisuuksia hyödyntää teknologiaa omassa opetuksessa. Puuttuva rohkeus ja uskallus kokeilla uusia opetusryhmän edessä voi rajoittaa teknologiakokeiluita, mikäli omia valmiuksia toimia teknologian kanssa ei koeta riittävän vahvoiksi tai oman auktoriteetin tai kasvojen menettämisen pelko tilanteessa koetaan liian suureksi. Kuitenkin digitalisoituva yhteiskunta, opetussuunnitelmien vaatimukset sekä mm. ylioppilastutkinnon koejärjestelyjen sähköistyminen ovat lisänneet teknologisten taitojen ja ajattelun omaksumisen merkitystä opetuksessa.

Tässä työssä on esitelty teknologian integraation esteiden ylittämisen malli, joka huomioi ne tunnistetut esteet, joita teknologian siirtymisessä suunnittelusta käyttöön on. Jotta nämä esteet voitaisiin sujuvasti ylittää ja mahdollistaa teknologian integraatio osaksi oppimisen ja opetuksen käytänteitä, tulisi opettajille tarjota systemaattisesti monipuolista ja heidän aitoa tarvettaan vastaavaa täydennyskoulutusta sekä oikea-aikaista tukea. Teknologian käyttö dynaamisessa luokkahuoneympäristössä asettaa opettajalle monentasoisia haasteita, joihin osa opettajista on jo nyt valmiita vastaamaan, kun taas osa vasta opettelee teknologian peruskäyttöä. Onkin tärkeää ymmärtää opettajien taitojen ja tietojen heterogeenisuus suunniteltaessa mahdollisia koulutuksia ja tukimuotoja, jotta tukea voidaan tarjota opettajan tarpeesta ja lähtökohdista käsin. Vasta, kun hyvin suunniteltu oppimisteknologia saadaan integroitua osaksi opettajien ja oppilaiden arkea, voidaan sen tuottamasta arvosta oppimiselle ja opetukselle päästä nauttimaan.

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INCLUDED ARTICLES

I

USABILITY CHALLENGES IN DIGITAL LEARNING SOLUTIONS

by

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Usability challenges in digital learning solutions

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Usability is a key element in successful software. Ensuring the technical usability of a learning solution enables users to focus on their main task, learning. The purpose of this paper is to demonstrate the results of heuristic usability evaluations of digital learning solutions. Heuristic evaluations were conducted on 24 digital learning solutions from one country (Finland) and two country groups (Asian countries and Spanish speaking countries) concentrating on the usability of the user interface of each evaluated solution. The main results of this study indicate that a few heuristics cover the majority of all usability problems (UPs) observed in learning solutions, but these heuristics contain a relatively low proportion of the UPs rated as severe. The results also indicated differences in the usability problems (UPs) observed between different types of digital learning solutions and between digital learning solutions from different countries or country groups.

Keywords—usability; heuristic evaluation; digital learning solutions; usability problems

I. Introduction

Use of digital learning solutions in learning and teaching has become more popular over past decades (e.g. [12]). There is a wide variety of different digital learning solutions available, but also digital solutions that have not been originally designed for learning are utilized [7]. However, in many cases digital solutions are used in ways their designers had not imagined [9]. Digital solutions that have not been designed for educational use like social media tools [2], virtual worlds [28] and mobile devices [9] are also used in teaching and learning. The use of digital solutions that have not been designed for educational use can lead to challenges with usability [15], particularly in light of usage purpose and context [9].

Evaluating the usability of a digital solution can be approached via various techniques. Techniques include methods for user testing and usability inspections conducted by usability experts. User testing methods range from simple user testing situations [8] to usability questionnaire techniques ([3][27]). Usability inspection techniques are used mainly to assess the technical usability of a digital solution by means of heuristic usability evaluations [16], cognitive walkthroughs ([20][29]), time-testing [25] and error counting [4]. These methods have value for various situations, with certain outcomes in mind and can be used on various types of software.

Usability challenges have been explored on various devices, software and services including medical devices [31], software for work contexts [19], e-learning platforms [5], digital textbooks [10] and e-learning courses [30]. Common usability challenges in devices, software and services cover various topics including consistency, informing users about system status, providing feedback and more guidance to users, navigational structures and aesthetic integrity of the user interface ([5][10][30]). Although the topics covered in previous research vary, based on the set of heuristics used, a commonly shared feature seems to be that the majority of usability challenges have concentrated only on a small amount of key issues such as consistency and informing the user about system status ([5][19][30][31]).

Mayes and Fowler [13] argue that the usability of digital learning solutions cannot be measured similarly to software aimed for work contexts. They point out a paradox in digital learning solutions, in that usability is not necessarily a prerequisite for deep learning and argue that approaching learning as a conventional task can be a misguided approach, since learning is commonly a "by-product of doing something else" and that it is this "something-else" that should be supported [13]. However, Kukulska-Hulme [9] raises the issue that for the most part, mobile learning happens on devices that have not been designed with educational use in mind. All devices and software, whether they are designed for educational use or not, could benefit from ensuring a basic level of technical usability, because it enables learners to focus on their learning tasks instead of tackling problems caused by technology [22].

In this study the aim is to further explore usability challenges in digital learning solutions. The paper is based on an ongoing Finnish research project "Systemic Learning Solutions (Systech)", which aims at developing research-based principles for the design and use of digital learning solutions (see [6]), where usability evaluation is part of the principles for the design of learning solutions. Main aim of the usability evaluation was to identify usability challenges or problems (UPs) and their severity with heuristic evaluations of digital learning solutions. The study also examined tentative differences in two background variables: firstly, between types of digital learning solutions and secondly, between countries in which the learning solutions were designed.

The following sections address these questions through breaking down and explaining the nature of heuristic evaluations, as well as outlining the empirical process of this study. The results are presented in terms of usability issue type and distribution of usability percentages. Differences between country groups are reflected in the results discussions, which subsequently inform our conclusion which focuses on existing heuristic evaluation methods while proposing improvements based on this study's findings.

II. Heuristic evaluation

Heuristic evaluation is a systematic method to evaluate the usability of a user interface of software [16]. The heuristic evaluation of software user interfaces is conducted by a small number of evaluators, who go through the interface and judge how well its design complies with commonly accepted usability principles called 'heuristics' ([1][17]). Heuristic evaluation is one of the most commonly used usability inspection methods, due to its low cost in comparison with other testing methods and intuitiveness of use [30].

Heuristic evaluations have been developed from extensive design principles [26] to more manageable sets of heuristics ([16][22]) that can be used in conducting these heuristic evaluations (Table I). Heuristic evaluations are commonly conducted in a way similar to that suggested by Nielsen and Molich [16], which have been further developed by Nielsen ([17][18][20]). Furthermore, Nielsen's [20] work on improving the effectiveness and enhancing the explanatory power of heuristic evaluations has made heuristic evaluation a popular subject of study.

TABLE I. NIELSEN'S [21] TEN USABILITY HEURISTICS FOR USER INTERFACE DESIGN

Heuristic	Description
Visibility of the system status	The system should always keep users informed about what is going on, through appropriate feedback within reasonable time.
Match between system and the real world	The system should speak the users' language, with words, phrases and concepts familiar to the user, rather than system-oriented terms. Follow real-world conventions, making information appear in a natural and logical order.
User control and freedom	Users often choose system functions by mistake and will need a clearly marked "emergency exit" to leave the unwanted state without having to go through an extended dialogue. Support undo and redo.
Consistency and standards	Users should not have to wonder whether different words, situations, or actions mean the same thing. Follow platform conventions.
Error prevention	Even better than good error messages is a careful design which prevents a problem from occurring in the first place. Either eliminate error-prone conditions or check for them and present users with a confirmation option before they commit to the action.
Recognition rather than recall	Minimize the user's memory load by making objects, actions, and options visible. The user should not have to remember information from one part of the dialogue to another. Instructions for use of the system should be visible or easily retrievable whenever appropriate.
Flexibility and efficiency of use	Explanation: Accelerators -- unseen by the novice user -- may often speed up the interaction for the expert user such that the system can cater to both inexperienced and experienced users. Allow users to tailor frequent actions.
Aesthetic and minimalistic design	Dialogues should not contain information which is irrelevant or rarely needed. Every extra unit of information in a dialogue competes with the relevant units of information and diminishes their relative visibility.
Helping users recognize, diagnose, and recover from errors	Error messages should be expressed in plain language (no codes), precisely indicate the problem, and constructively suggest a solution.
Help and documentation	Even though it is better if the system can be used without documentation, it may be necessary to provide help and documentation. Any such information should be easy to search, focused on the user's task, list concrete steps to be carried out, and not be too large

One branch of heuristic evaluation study has focused on increasing the explanatory power of heuristics in analyzing the usability of digital learning solutions (e.g. [22][23][24]). Various attempts have been made to create a set of heuristics that includes both the technical [20] and pedagogical usability aspects [22]. The main aim of these heuristic sets, that combine technical and pedagogical usability has been to emphasize the need for inclusion of pedagogical features when assessing the usability of digital learning solutions ([14][22][23]). In addition, Magoulas, Chen, and Papanikolaou [11] have integrated heuristic evaluation with layered evaluation of adaptive learning environments.

III. Research Design

The main aim of the study was to evaluate the amount and severity of usability problems (UPs) in digital learning solutions. In addition, the study aimed at exploring the tentative differences between country groups in which the evaluated digital learning solutions are designed and digital learning solution types.

A. Evaluation procedure

The usability evaluation of digital learning solutions were conducted via heuristic evaluation based on Nielsen's [21] ten usability heuristics (see Table I). The usability evaluations were conducted by two researchers who individually / independently evaluated each digital learning solution and reported their observations. Each of the observations was: marked with one or more heuristics to which it related to; a description of the usability problem (UP); a rating of the severity of the problem; and a suggestion on how to fix the problem. The severity of each UP was marked as either minor, moderate or major according to whether the digital learning solution could be used or if the UP prevents the use of the digital learning solution or a part of it.

The evaluators were researchers with a sizeable knowledge about usability and usability testing methods, but differed in their other expertise. One of the researchers was experienced in the fields of usability, user experience and design. The other researcher was experienced in the fields of usability, education and pedagogical use of information and communication technology.

B. Description of digital learning solutions

The heuristic evaluation was conducted for altogether 24 digital learning solutions from five countries. These digital learning solutions were selected based on suggestions from Systech research and company partners in five countries: Chile, Hong Kong, Finland, South Korea and Spain. These individual countries were later grouped based on cultural similarity to two country groups: Asian countries (Hong Kong and South Korea) and Spanish speaking countries (Chile and Spain). Finland was left as an individual country since the amount of digital learning solutions available from Finland (10) exceeded the combined totals of learning solutions for either of the other country groups Asian countries (8) and Spanish speaking countries (6).

These digital learning solutions represent a diverse sample of technological learning solutions, with different use contexts (from classroom use to extracurricular activities), usage purposes, intended learning outcomes and user groups (from preschoolers to adult learners). They were divided into two groups, namely 1) content learning solutions (altogether 12 digital learning solutions), and 2) tools and platforms (12 digital learning solutions). Content learning solutions focused on teaching a particular preset of data or skills, with none or only minimal options for users to modify content. The selection of content learning solutions represented online learning environments for various subjects (e.g. mathematics, languages and music). They offered experiences in content enrichment, games and exercises. Tools and platforms were solutions for creating or distributing content from multiple sources or they were collections of materials. The tools and platforms were course material and other content (e.g. routes) creation software, solutions for testing knowledge, video and game platforms and platforms for applied learning, such as physics simulations or driver education.

C. Analysis

The data consisted of 24 heuristic evaluation report sheets, where one sheet combined all the observations made by two evaluators about a digital learning solution. Evaluator data was combined and observations of the same usability problem were combined to remove redundancy. There were altogether 418 observed usability issues in the 24 evaluated digital learning solutions. These observations consisted of description of the issue, severity rating, suggested solution for the issue and one more heuristics it violated. One observation could be a violation of one or more heuristics and these occurrences of heuristics were counted as usability problems (UPs). The total amount of usability problems for all 10 heuristics was 509, which is higher than the amount of observations (418), showing that there were numerous instances where individual usability issues addressed more than one heuristic.

The data was analyzed according to the amount of UPs and severity ratings for each heuristic. The UP amount and severity ratings were further analyzed according to country group the digital learning solutions belonged to and the type of digital learning solution they represented.

IV. Results

A. Usability problems of digital learning solutions

1) Amount: The data analysis revealed large variation in the amount and severity of usability problems across the ten heuristics (Table II). It was realized that five heuristics covered altogether 73 % of the observed usability problems.

The most frequent heuristic was consistency and standards with 27 % of total UPs. The distribution of other four most frequent heuristics varied between 10-12 %. For the remaining five heuristic the distribution varied between 5-7 %.

2) Severity: Variation in the severity ratings within heuristics was for the most part shared by heuristics and only two showed a different variation of severity ratings. Eight heuristics had a clear pattern of having high amounts of minor usability problems (54-74 %); a modest amount of moderate UPs (12-31%) and a relatively low amount of major usability problems (3-16%). Out of these eight heuristics only one heuristic match between system and the real world had more major (16%) than moderate usability problems (12%), while others had more moderate (19-31%) than major usability problems (3-16%). The greatest difference in severity ratings could be observed in two heuristics: 'error prevention' and 'helping users recognize, diagnose, and recover from errors', which have 40-52% of major usability problems, 26% modera*te UPs and 22-34% of minor UPs.*

3) Cross-analysis of amount and severity: The five most frequent heuristics also share the feature of having more than 59% of usability problems connected to them given a severity rating of being minor usability problems. The three heuristics with the lowest to third lowest percentage of all observations show a similar trend by having more than 53% of all observed usability problems rated as minor usability problems and under 16% rated as major usability problems. The remaining two heuristics that deal with errors, 'error prevention' and 'helping users recognize, diagnose, and recover from errors' both share a feature of having more than 39% of all usability problems rated as major usability problems, which will be discussed in more detail later on in this paper.

B. Description of significant heuristics/usability problems

1) Heuristic category - Consistency and standards: The data analysis revealed large variation in the amount and severity of usability problems across the ten heuristics (see Table II). It was realized that five heuristics covered altogether 73 % of the observed usability problems. The most frequent heuristic was 'consistency and standards' with 27 % of total UPs. The distribution of other four most frequent heuristics varied between 10-12 %. For the remaining five heuristic the distribution varied between 5-7 %.

TABLE II. UPS AND SEVERITY RATINGS

		Severity		
Heuristic	***UPs (%)***	***Minor (%)***	***Moderate (%)***	***Major (%)***
Consistency and standards	27.1	73.9	23.2	2.9
Visibility of the system status	12.2	59.7	24.2	16.1
Match between system and the real world	12.0	72.1	11.5	16.4
Aesthetic and minimalistic design	11.2	73.7	19.3	7.0
User control and freedom	10.2	67.3	23.1	9.6
Error prevention	7.5	34.2	26.3	39.5
Flexibility and efficiency of use	5.7	69.0	24.1	6.9
Help and documentation	5.1	53.8	30.8	15.4
Recognition rather than recall	4.5	69.6	21.7	8.7
Helping users recognize, diagnose, and recover from errors	4.5	21.7	26.1	52.2
Total	100.0	64.4	22.2	13.4

When looking at differences between three groups of countries (Asian countries, Finland and Spanish speaking countries) some differences in the severity ratings between country groups can be observed (Table III). The distribution of severity ratings in the heuristic 'consistency and standards' shows that digital learning solutions from both Asian countries and Spanish speaking countries have a high number of UPs rated as minor (82-85%). Differing distribution can be observed in the Finnish solutions where there are 60 % of minor UPs and 35% of UPS with moderate severity.

TABLE III. DIFFERENCES IN USABILITY PROBLEMS FOR THREE HEURISTICS IN FINLAND AND TWO COUNTRY GROUPS

		Asian countries			**Finland**			**Spanish speaking countries**		
Heuristic	***All UPs (%)***	***Minor (%)***	***Moderate (%)***	***Major (%)***	***Minor (%)***	***Moderate (%)***	***Major (%)***	***Minor (%)***	***Moderate (%)***	***Major (%)***
Consistency and standards	27.1	81.6	18.4	0.0	59.2	34.7	6.1	84.6	7.7	7.7
Error prevention	7.5	33.3	33.3	33.3	30.8	30.8	38.5	50.0	0.0	50.0
Helping users recognize, diagnose, and recover from errors	4.5	30.0	40.0	30.0	9.1	18.2	72.7	50.0	0.0	50.0

TABLE IV. USABILITY PROBLEMS IN CONTENT SOLUTIONS AND TOOLS AND PLATFORMS FOR THREE HEURISTICS

	Content solutions	**Severity**			**Tools and platforms**	**Severity**		
Heuristic	***% of all content solution UPs***	***Minor (%)***	***Moderate (%)***	***Major (%)***	***% of all tools and platforms UPs***	***Minor (%)***	***Moderate (%)***	***Major (%)***
Consistency and standards	31.7	78.1	20.3	1.6	24.1	70.3	25.7	4.1
Error prevention	9.1	32.1	28.6	39.3	5.0	40.0	20.0	40.0
Helping users recognize, diagnose, and recover from errors	4.5	44.4	11.1	44.4	4.6	7.1	35.7	57.1

This difference could be further explored by looking at the distribution of usability problems within the heuristic consistency and standards between two types of digital learning solutions (Table IV). Overall trend in both content solutions and tools and platforms is similar when looking at UPs from all 24 digital learning solutions. Most of the UPs 70-78 % are rated minor, 20-26 % as moderate and 2-4 % as major.

2) Heuristic category: Preventing and recovering from errors: The heuristics 'helping users recognize, diagnose, and *r*ecover from errors' and 'error prevention' contain respectively 5 % and 8 % of all UPs (Table II). Even though the amount of UPs is relatively low in both heuristics the amount of UPs rated as major. 'Helping users recognize, diagnose, and recover from errors' and 'error prevention' have a distribution of 22-34% of minor, 26% moderate and 40-52% major UPs. UPs for the two heuristics consisted of issues with input formatting, password generation and recovery, nonfunctional items and error situations and messages.

The variation between Asian countries, Finland and Spanish speaking countries show some differences in the severity ratings of the heuristics 'helping users recognize, diagnose, and recover from errors' and 'error prevention' can be observed (Table III). These two heuristics have both in Asian countries and Spanish speaking countries a similar distribution within both country groups. Digital learning solutions from Finland show a clearly different distributions between these two heuristics. 'Error prevention' shows a pattern that is similar to the digital learning solutions from Asian countries in regards to the severity ratings, with all severity rating groups having almost one third of all UPs. However 'helping users recognize, diagnose, and recover from errors' shows a clear difference in distribution having 9 % minor, 18% moderate and 73 % major UPs.

When comparing digital learning solution types (content solutions and tools and platforms) in respect to the two heuristics, 'error prevention' and 'helping users recognize, diagnose, and recover from errors' (Table IV), there are merging patterns in the distribution of severity ratings. Content solutions have a similar pattern for both heuristics with percentages of minor (32-44 %) and major (39-44 %) being similar and the amount of moderate UPs being the smallest (11-29%). Tools and platforms have similar pattern in 'error prevention' with 40% minor, 20% moderate and 40% major UPs, but not in 'helping users recognize, diagnose, and recover from errors'. Tools and platforms a distribution of 7% minor, 36% moderate and 57% major UPs in helping users recognize, diagnose, and recover from errors.

V. DISCUSSION

The main results from this study verify the knowledge from earlier research ([5][19][31]) that a few heuristics cover the majority of all usability problems. Significant amount (27%) of UPs were categorized under one heuristic, namely 'consistency and standards', and the five heuristics with highest amount of UPs covered 73 % of all UPs. However, even though these heuristics covered the majority of all UPs more than half of the UPs in these heuristics were rated as minor. In general UPs in these heuristics were considered by the evaluators as issues that may hinder the learnability and efficiency of use and the overall user experience, but do not necessarily prevent completing tasks with the digital learning solution.

Heuristics that showed the largest proportion of major usability problems were 'error prevention' and 'helping users recognize, diagnose, and recover from errors'. These two heuristics represent 12 % of all UPs, with more than half of the UPs rated as major UPs. This would suggest that UPs related to heuristics dealing with errors are mainly perceived as UPs that should be fixed most urgently. However, in this study the amount of observations under heuristics 'helping users recognize, diagnose, and recover from errors' and 'error prevention' is too low to make conclusions about the differences between country groups and digital learning solution types. The results of this study suggest that there is a difference in the distribution of severity ratings of these two heuristics compared to the other eight heuristics that could be further explored with additional research. In previous research there has also been indications that the distribution of severity ratings might vary between heuristics ([19][30]).

The two types of digital learning solutions, tools and platforms and content learning solutions, showed a similar distribution of amount and severity ratings in almost all of the heuristics analyzed in more detail. Only one heuristic ‘helping users recognize, diagnose, and recover from errors’ demonstrated a shift in tools and platforms having more major UPs and moderate UPs than minor UPs. The category of tools and platforms consisted of a variation of digital learning solutions and in future research endeavors it might be relevant to divide the digital learning solutions in more precise subcategories.

There are four major limitations to this study: amount of digital learning solutions, digital learning solution types, number of evaluators and the set of heuristics used in the study. The first limitation is the sample size from each country or country group is not the same (6-10 digital learning solutions), which hinders the cross cultural analysis of the results. In future research the amount of learning solutions from each country or country group should be the same. Second limitation concerns the variation of digital learning solution types of from each country or country group and in future research each country should be represented by the same amount of each learning solution type. Furthermore the categorization of digital learning solutions might require additional research, since two large groups, content learning solutions and tools and platforms, might not be enough to explain the differences between digital learning solutions. Third limitation is the amount of evaluators, which in this study was two, while the recommended amount for heuristic evaluation is at least three evaluators [17], and in future research at least three usability experts will be used. The fourth limitation is the set of heuristics [21] used, which has been designed with the technical usability in mind and do not take pedagogical concerns into account. Pedagogical concerns in digital learning solutions will be addressed by further research of the digital learning solutions with pedagogical experts.

The suggested minimum number of evaluators for heuristic evaluation is three as was discovered by Nielsen [17] However as Nielsen’s [17] results suggested, double specialists can find a significantly higher amount of UPs than regular usability specialists. Double specialists in Nielsen’s [17] study consisted of usability experts who also had experience of the software type being evaluated. In this study two usability researchers, who had further experience of either learning solutions or interface design, which would classify them as double specialists in their respective fields. This would in general support the use of only two usability experts. However, additional experts could have benefitted the overall coverage of all UPs in the evaluated digital learning solutions and therefore in future research endeavors this matter should be addressed.

In general the set of ten heuristics [21] was considered by the evaluators to be useful, but for some usability problems it was difficult to find a suitable category and a broader set of heuristics might be needed. The evaluators noted that in particular problems regarding situations where errors had already occurred or features were not functioning at all, the current heuristics did not offer a category suitable to describe these types of UPs. These types of observations were categorized under the closest suitable heuristic such as error prevention, even though they do not completely fit the category.

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II

TOWARDS THE LEARNING TECHNOLOGY USABILITY FRAMEWORK

by

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Chapter 12
Towards the Learning Experience Technology Usability Framework

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ABSTRACT

The availability of learning technology has increased over past decades; however, severe usability issues that cause adverse effects on the learning experience can be found in many available technologies. Learning solution usability is commonly evaluated by focusing on either technical or pedagogical usability and rarely both. This artificially separates the two important aspects of learning technology usability. This chapter provides a new framework for designing and evaluating learning solutions that synthesizes the above usability types to consider them a part of a complex and dynamic whole comprising of learning, technological design, content-related issues and context. The proposed Learning Experience Technology Usability (LETUS) framework will help bridge the gap between theory and practice to provide learning solutions that have usability in relation to both the technological and learning related aspects of the solution.

INTRODUCTION

Development in and access to learning technology has been increasing over the past few decades. While vast progress has been achieved in relation to research and design of learning solutions, still major work needs to be undertaken in order to properly understand the dynamics and underlying processes involved in technology mediated learning. There are numerous gaps and variances between industry design-

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based knowledge and academic knowledge regarding the topic of usability, especially in relation to the design of digital learning technologies (Lee, Trauth & Farwell, 1995; Rynes, Bartunek & Daft, 2001; Susman & Evered, 1978). Unfortunately, even with this basis it seems that the small and medium sized enterprises that dominate the digital learning technology scene (Tekes, 2015), do not necessarily have the resources to develop their products to their full potential. Influential factors contributing to this include misinformed or absent knowledge regarding the specifics of designing digital learning solutions for various learning experiences.

Rather than simply specifying notions such as learning, teaching, education and pedagogy, here, the term learning experience is adopted, to emphasize the nature of learning as a continual, and ever changing flow of knowledge development (Dewey, 1938/1997). Through recognizing learning as an experiential process, connotations of performance and outcomes-based learning, and the necessity to specify parameters for its measurement is alleviated. The term learning experience refers to the impressions, sentiments and memories, which go on to provide the building blocks for further learning encounters, processes, and in turn experiences, across the curriculum, in a wide spectrum of contexts (see e.g., Kolb, 2014). As psychologist and philosopher John Dewey (1938/1997) states in his seminal Experience and Education, that while "[e]xperience and education cannot be equated with one another…every experience lives on in further experiences" (p. 27) which ultimately affects how individuals approach learning and what they learn as a result.

The aim of this chapter is to provide a new framework for designing learning solutions that promotes and enhances learning and can be used without significant technical barriers or issues hindering the learning experience. The data for this chapter consists of an analysis of previous research, and original empirical research on both technical and pedagogical usability of recently developed digital learning solutions. Previous work on technical usability has revealed several issues related to the set of heuristics used (Nielsen's heuristics, 1994a) in this study (e.g., see Mayes and Fowler, 1999; Nokelainen, 2006). In this paper, previous frameworks for the usability of digital learning solutions are also scrutinized. However, the frameworks of previous scholars mentioned in this chapter are valuable resources as they inform the basis of a more suitable evaluative framework through which the usability of digital learning solutions maybe be both assessed and developed.

As a result, this work provides a new revised framework that can be used, when designing and evaluating software intended for educational and learning purposes. The proposed Learning Experience Technology Usability (LETUS) framework aids in bridging the gap between theory and practice within the field of learning and usability studies. This subsequently enables the provision of digital learning solutions that have usability in relation to both the technological and learning related aspects of the solution. What many frameworks neglect is the relevance of the context of use and the situation in which the learning solution will be used, as well as the sometimes unpredictable nature of learning (Mayes & Fowler, 1999). Efforts have been made to create methods to design learning technology with a broader view of usability, but there still remains a need for an easy-to-adopt and efficient way to design the usability of learning technology in a way that includes both the technical and pedagogical aspects, as well as knowledge about the learning experience and context as they all impact the overall usability of the chosen technology. The proposed framework attempts to combine all these perspectives of digital learning technology usability to provide an efficient way of evaluating the technology used to support learning experiences.

The chapter begins with a background into previous studies addressing the issue of usability in digital (e-learning, online learning, computer-aided etc.) learning solutions. Here, some of the main contributions to the field are discussed, which is followed by the canvassing of existing models intended to solve the digital learning solution usability query. The influencing factors of the usability of learning experience technology chapter delves deeper into scientific research and paradigms, which contribute to the usability of digital learning solutions in specific contexts.

BACKGROUND

Previous studies have shown that severe usability issues can be found in many of the available learning technologies and that those issues can have adverse effects on the learning experience, as well as, continued use of the technology (e.g. Ardito, De Marsico, Lanzilotti, Levialdi, Roselli, Rossano & Tersigni 2004). When considering technology for learning, there are two sides to usability that need to be considered: technical and pedagogical. A common way to evaluate usability cost efficiently is to have experts conduct a heuristic evaluation on the technology with or without additional user testing. Even though these checklist approaches have been criticised (e.g. Squires & Preece, 1999) they are still widely used and are an inexpensive way to detect at least some of the usability issues in the learning solution. However, heuristic evaluations usually only focus on either technical or pedagogical usability, seldom both (Ardito et al. 2004; Lanzilotti, Ardito, Costabile & De Angeli, 2006). Furthermore, attempts have been made to create pedagogical usability heuristics derived from technical usability principles (e.g. Nokelainen, 2006), but these frameworks fail to address the technology related concerns. Also, some frameworks have addressed this by creating an evaluation framework for assessing the complete usability of learning technology without creating any artificial separation between the two important aspects of learning technology usability (e.g. Hadjerrouit, 2010).

However, there is still a demand for a more holistic way of addressing usability and user experience aspects in learning technology during the early stages of the learning solution design process. This means that learning technology usability should be seen not as an objective factor within the ability to technically use the solutions for learning purposes, but rather, a fluid component intimately connected to user experience, contextual and application factors that operate in an ecosystem to enhance learning experience. To illustrate this, it is beneficial to consider the colours, images and even examples used within the application. While working technically, socially and aesthetically in one context, whether that be cultural or even learning context (e.g. age, school grade, school environment etc.), it may not be entirely suitable for other contexts. This suitability, and ultimately usability (perceived and actual usability) is determined by: literacy levels and literacy standards (formatting, spacing, font, alphabet, language); underlying connotations of colours, how images correspond with the lived realities of learners and whether or not they are appropriate - can the learner identify with the characters and images being represented?; and are the examples applicable or even acceptable to the learner?

Moreover, one of the main issues that is often neglected both in relation to learning technology as well as more traditional education and learning scholarship alike, are the immeasurable qualities of learning encounters. These include the experiences, memories and non-evaluated learning (learning occurring outside the syllabus) that may stay with the learner for the rest of their life. These learning experiences may affect future experiences whether in direct relationship to the subject in question (mathematics, science, language etc.), or to the technology itself (Dewey, 1938/1997). On this note, it is important to remember that not only should the interaction design of learning solutions take into account the fact that positive usability will influence the student's attitudes and capacity to learning the subject material through the application, and subsequent related learning experiences, but it will also influence the student's attitudes and emotions towards the mediating technology itself. That is, poor design and implementation of information technology often results in states such as technophobia (Brosnan, 2002; Marquardt & Kearsley, 1998). Technophobia has been discussed quite extensively from the perspective of e-learning, yet devising an effective paradigm to address the interrelationship between the numerous moving components has proven challenging (Juutinen, 2011).

PERCEIVABLE, OPERABLE, UNDERSTANDABLE, ACCESSIBLE, ROBUST

Many of the challenges observed in the literature review, the results of which are presented in the following section, in combination with empirical findings, can be summarized into five main elements: the perceivable, the operable, the understandable, the accessible and the robust. These elements correspond with the four principles of the Web Content Accessibility Guidelines (Caldwell, Reid, Vanderheiden, Chisholm, Slatin, & White, 2008), which state the importance of perceivability, operability, understandability and robustness in cognitive language and learning areas. Perceivability refers to the rate to which information in the design can be perceived (Caldwell et al., 2008), that is, information (text, images, and other sensory information) that is apparent and easily noticed. If specific elements or information is either too small, located in an unusual position (not consistent with usability standards) or even hidden in menus or behind links, it is not adequately perceivable (Krug, 2014; Nielsen, 1995). Operability is affected by both functions within the software design, as well as hardware and input devices such as keyboards, touchscreens, voice and gestural interfaces etc. Operability requirements vary according to the needs and capabilities of the users, and these are contingent upon both physical capabilities as well as cognitive capabilities (Caldwell et al., 2008). For instance, use of animations within a learning environment should be controlled and carefully deliberated, as these often pose challenges to accessibility.

Accessibility in this chapter incorporates the above mentioned WCAG model (Caldwell et al., 2008), with other accessibility issues such as multi-platform and device usability, online-offline possibilities, and overall consideration for how cultural, social and economic circumstances influence learners' abilities to access and use the software solutions. Moreover, understandability is included within this accessibility, as language in particular, and the way that it is applied through either natural language (e.g., English, Finnish etc.) as well as system and literary logic (e.g. reading flow and direction) affect the way learners access information. Robustness of the solutions stems from the multi-platform, multi-device accessibility considerations, to account for the varied and personalised way in which people use and combine devices and software - both from the teaching and learning perspectives - and whether or not there are possibilities to seamlessly combine these varied components (Cardwell et al., 2008). Furthermore, to refer once again to the perceivable element of the findings, perceived usability, as described by scholars such as Tractinsky (1997) and Norman (2005), incorporates aesthetics and the role of emotions, and how people think (imagine) they are able to use a system, as integral components in understanding the usability of design.

CANVASSING THE MODELS FOR LEARNING EXPERIENCE USABILITY VALUE

Regarding the empirical section, Jakob Nielsen's (1994a) ten usability heuristics were utilized to evaluate 24 learning solutions from five countries. Before adopting these heuristics awareness of their relationship within the framework of digital learning technologies (e.g., see Nokelainen's (2006) pedagogical usability) was already formed. However, it was necessary to concentrate on the technical aspects of the learning solutions, before endeavouring to understand the dynamics of the various learning situations and contexts on the pedagogical usability itself. On this note, previous work by Kenttälä, Kankaanranta, Rousi and Pänkäläinen (2015) highlights the differences in the distribution of observed usability problems based on Nielsen's heuristics. Moreover, a significant outcome of this study was that 73% of all observed usability issues could be categorized under five heuristics which were: 1) consistency and standards; 2) visibility of the system status; 3) match between system and the real world; 4) aesthetic and minimalist design; and 5) user control and freedom).

These findings can be explained by the diversity of digital learning solutions evaluated, and their intended application contexts varying from tool-based usage, to content-rich pedagogy, geography and mathematics. From the design perspective, another explanatory factor involves the fact that when presented with such diversity in any number of everyday situations (from school to work, domestic and leisure time environments), the key characteristics influencing people's acceptance of, behavior towards, engagement with, as well as overall usability and user experience is that digital solutions need to be: consistent in style and logic (Krug, 2014; Nielsen, 1994a); visible among the masses, and visible in terms of communicating operation logic (Norman, 2013); connected in content and language with the external environment (social, cultural, physical) (Nielsen, 1994b; Squires & Preece, 1999); aesthetically pleasing which combines both cognitive and hedonic elements (Diefenbach & Hassenzahl, 2011); and enable the user to feel in control (Hassenzahl, Diefenbach & Göritz, 2010).

In the previous study by Kenttälä et al. (2015), issues described by these heuristics were mainly given low severity ratings. The heaviest concentration of severe usability issues could be found under two heuristics (error prevention and helping users recognize, diagnose, and recover from errors) which both received lower overall amounts of usability issues (Kenttälä, et al., 2015). These observations also raised some issues regarding the interrelated nature between technical and pedagogical usability which will be further analysed to create a holistic view of learning solution usability. Moreover, an attempt will be made to close the artificial divide between technical and learning related (previously pedagogical usability) aspects of usability, by examining how the two sides of usability support and complement each other to form a new framework that aids designing and evaluating learning solution usability.

The LETUS framework was developed by analyzing 13 frameworks and complemented by knowledge gained from analyzing data gathered from international expert evaluations about design and use of learning solutions (see Mäkelä 2015). The international expert evaluations consisted of four parts: overall impression, education, culture and design, out of which this chapter focuses on design. For this purpose 113 evaluations from 7 countries (Chile, Finland, Hong Kong, Singapore, South Korea, Spain and United Arab Emirates) were coded by two researchers. The coded data was then checked for reliability and the explanatory power of the coding framework was developed accordingly. The individual work of each researcher was then combined and one unified coding framework (Table 1) was created.

This framework was then compared and analyzed side by with other frameworks and models presented in Table 2. The frameworks analyzed had different focuses, yet complemented one another in order to

Table 1. Coding framework for design portion of the international expert evaluations

Coding Framework
Feedback, social media and other features
Guidance
Differentiation for different user groups
Learning methods and practices
Connection with user's everyday reality
Multimedia
User experience and perceived usability
Navigation and structure
Access and infrastructure
Scalability
Suitability
Cultural relevance

Table 2. Additional frameworks analysed

The Arcs model of motivational design (Keller, 1987)	Pedagogical usability (Nokelainen, 2006)
Usability heuristics (Nielsen 1994a)	A conceptual framework for using and evaluating web-based learning resources in school education. (Hadjerrouit, 2010)
Usability Heuristics for E-Learning Design (Mehlenbacher, Bennett, Bird, Ivey, Lucas, Morton, & Whitman, 2005)	The Design Principles for Flow Experience in Educational Games (Kiili, Freitas, Arnabb & Lainema, 2012)
Gameflow Model (Sweetser & Wyeth, 2005)	Pedagogical playability heuristics (Tan, Goh, Ang & Huang, 2013)
Events of instruction (Gagné, Wager, Golas, Keller, & Russell, 2005)	Computer-Assisted Assessment (CAA) Heuristics (Sim & Read, 2015)
Technological Pedagogical Content Knowledge: A Framework for Teacher Knowledge. (Mishra, & Koehler, 2006)	Coding framework for design portion of international Learning solution Expert Evaluations (Table 1)

form a more complete view of all the aspects that should be taken into consideration when designing or evaluating learning technology. The LETUS framework utilizes the basic structure of the Technological Pedagogical Content Knowledge model, or TPACK (Mishra, & Koehler, 2006), with further emphasis on context related features of the technology learning experience.

THE LEARNING EXPERIENCE TECHNOLOGY USABILITY FRAMEWORK

The core of the Learning Experience Technology Usability (LETUS) framework is formed by a coding framework (Table 1) created through the analysis of 113 expert evaluation reports from 7 countries, where expert evaluators evaluated the usability and design of nine learning solutions (see Mäkelä 2015). However, since the framework has been developed through one set of data and for a particular use, the explanatory power and overall coverage of the framework has been furthered by comparing and combining its features with knowledge gained from previous frameworks. The knowledge gained from the coding framework based on the Expert Evaluation data was furthered by researching relevant frameworks, usability and playability heuristics currently available. Basic criteria for choosing the frameworks and heuristics for this chapter entailed that they had been used or created for the analysis of learning technology and games.

The LETUS framework has four basic components: Learning, Content, Technology and Context (Figure 1). These components can be further divided into subcomponents that form a basis for evaluation and design of learning solutions (Table 3).

Each of the components present in the LETUS Design framework comprise elements which are seen as not only essential for the innate qualities of the components, but are also integrated with the mechanisms of the other components. The combined features from individual frameworks (Table 3) outline the associated elements of each component. Integral to the learning component are: 1) guidance and instructions, collaboration, feedback and assessment - elements pertaining to social instructor-learner/learner-learner interaction, information which directs the student towards learning pathways, as well as indications of how the learner is progressing; 2) previous knowledge, skill development, differentiation and skills for learning - applied and metacognitive elements for knowledge and its development; and 3) confidence, motivation and creativity - the in-learner cognitive-emotional responses to the learning technology design. Innate within the content component are: 1) authenticity and relevance, concepts and goals - the inner logic of the content and motivation for its elements; and 2) readability and multimedia - the way in which the content is designed and supported by technical characteristics. Technology innate

Figure 1. The components of LETUS framework

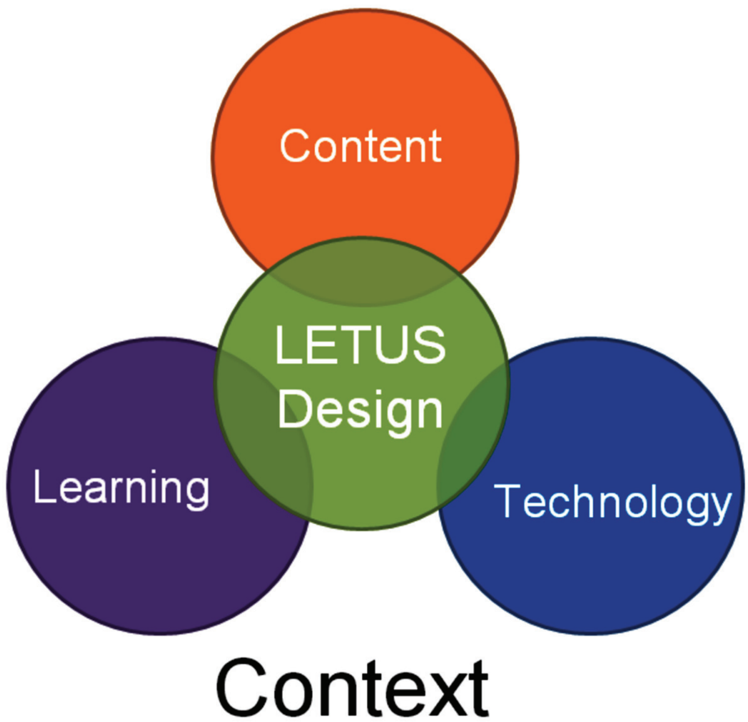

Table 3. Combined features from individual frameworks

Learning	Content	Technology	Context
Feedback	Goals	Flexibility	Satisfaction
Guidance and instructions	Authenticity and relevance	Control	Immersion and flow
Concentration and attention	Readability	Errors	Applicability
Collaboration	Concepts	Consistency	Added value
Assessment	Multimedia	Aesthetics and trust	Sociocultural relevance
Confidence		Navigation and intuitivity	
Motivation		Communication	
Skill development		Interaction	
Previous knowledge		Accessibility	
Differentiation		Scalability	
Skills for learning		Reliability and maintainability	
Creativity			

elements, or elements pertaining to the technical usability design, comprise: 1) flexibility, control, errors (error prevention or recovery), scalability, reliability and maintainability - the robustness of technical design and diversity (device, system and user) in use possibilities; 2) navigation and intuitivity, communication, interaction and accessibility - the language and interaction possibilities afforded by the design; and 3) aesthetics and trust - how users subjectively experience the composition of the solutions, and to what degree they rely on its credibility. Finally, context is constantly surrounding any technology or human-technology interaction. Moreover, context determines the validity and interpretation of the above mentioned elements. Thus, context influences the degree to which the learner and/or educator experiences: satisfaction, immersion and flow, applicability, sociocultural relevance, and quite significantly added value to the learning situation and desired outcomes.

FUTURE RESEARCH DIRECTIONS

Research in the field of educational technology usability needs to keep evolving to accommodate new technologies and designs. One trend that has been widely addressed over the past years has been the use of mobile technology in education (e.g. Soykan & Uzunboylu, 2015). Future developments particularly in AI and autonomous systems are drastically changing the ways in which learner-technology/ human-technology interactions are considered. Manual usability is fading into the background as the computer becomes ‘invisible’ (Streitz, Kameas & Mavrommati, 2007.) Key issues that affect artificial intelligence in education (AIED) are: intercultural and global dimensions, practical impact, privacy, interaction methods, collaboration at scale, effectiveness in multiple domains and role of AI in educational technology (Pinkwart, 2016). Similar issues were also observed in regards of educational technology in general in this chapter.

Further research is however needed to more profoundly include the learner perspective and learning theories and models in the design and evaluation frameworks. As a first step towards the Learning Technology Usability (LETUS) framework, this chapter is not a conclusive framework and the necessary learning aspects involved in technology aided learning need further analysis. Furthermore, some aspects relevant to learning with the aid of technology might need to be added to increase the explanatory power of the framework. Current focus in education is on learning 21st century skills (Binkley, Erstad, Herman, Raizen, Ripley, Miller-Ricci, & Rumble, 2012) and in order to be effective in preparing students to the 21st century skills, learning solutions should be designed to support learning of these skills. Incorporating these desired learning outcomes into design and evaluation criteria for learning solutions is a challenging task.

CONCLUSION

This chapter focused on usability of learning solutions and provided a new framework for evaluating and designing learning technology. The chapter articulates the need to revise current approaches to learning technology usability, through emphasising the importance of considering firstly the significance of learning as it is in educational situations (rather than taking a pedagogical, instructional design approach), and secondly consideration for learning as an experience, or series of experiences which cannot so easily be defined in terms of objectives and outcomes. Rather, the experience of technological design itself - user experience - and of the ways in which it supports learning processes should be considered the emphasis. Moreover, the role of context cannot be underplayed as this determines the ways in which both the technical design and learning material are experienced.

LETUS is the result and development of a rigorous literature review, combined with empirical study, into the factors that have been included in and scrutinised in decades worth of research into usability and learning technology design. It has combined the findings of these investigations with principles and directions explicated in agenda including the World Content Accessibility Guidelines and the presented modification of these which entail the perceivable, operable, understandable, accessible and robust. The emphasis of the LETUS model is on viewing learning via technological interaction as an experiential ecosystem which involves overlapping and dynamic exchange of components comprising the learning itself, content and technology within an all-encompassing context, which defines, directs and influences the subsequent learning experience. Here, rather than treating the two previously studied usability types involved in learning technology design - technical (Nielsen, 1994a) and pedagogical (Nokelainen, 2006) - as separate entities, LETUS seeks to synthesize elements pertaining to the learning, technological design, content-related issues and context. If any of these components are out of step with one another, or indeed the context as a whole, the learning experience derived from the learning technology interaction will be affected.

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KEY TERMS AND DEFINITIONS

Heuristic Evaluation: Usability inspection method assessing products compliance with commonly accepted usability principles.

Learning Experience: Feelings, memories and other factors that affect the way an individual learns or approaches learning.

Learning Solution: Software or other product that has been designed for educational or learning purposes.

Operability: Possibility and desire to use a product.

Pedagogical: Relating to teachers or education.

Perceivability: Being able to become aware of something through the use of one's senses (e.g. vision, touch, smell).

Usability: Learner's ability to use a product for its intended purpose efficiently without frustration.

III

LEARNING EXPERIENCE TECHNOLOGY USABILITY DESIGN FRAMEWORK

by

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Learning Experience Technology Usability Design framework

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Abstract: Using information and communication technology (ICT) for learning purposes has become more ingrained in curriculums and students' lives over the past decades. Commonly, the lack of understanding about learning and pedagogy, and more specifically their contexts, will lead to creating learning software that utilize outdated pedagogy or are lacking in critical aspects of pedagogical design. This has created a need to find cost efficient ways to address the multidimensional usability issues found in learning technology. Creating an engaging and pedagogically robust learning product is a complicated task that requires easily accessible knowledge about both the technological and learning related aspects in creating learning software.

The aim of this study is to explore and present the dimensions of learning technology even further, to provide a reinforced framework for creating and evaluating learning technology. For this purpose, we have developed the Learning Experience Technology Usability Design Framework. LETUS Design has both practical and theoretically rich components that combine heuristic evaluation, pedagogical theories and findings from extensive learning technology design expert evaluations. This paper aims at offering a more definite framework for evaluating the usability of learning technology in a holistic way. This work will further elaborate especially on the contextual aspects of digital learning technology design in the LETUS Design framework.

Introduction

The idea of using and designing technology for learning purposes has been around for several decades and there is a wide variety of different learning technology available today. When considering individual technologies, e.g. games, many teachers are still hesitant to use commercial games in their teaching (Becker & Jacobsen, 2005). This in turn creates a need for learning specific games and software. However, still today some of these learning technologies struggle with basic usability issues related to the technology, as well as learning, content and context related aspects of the products and systems (e.g. Kenttälä, Kankaanranta, Rousi & Pänkäläinen, 2015). Many of these issues could easily be redesigned during early stages of development. However, left without action, become costly or even inefficient, when attempting to fix them during later stages of development (Boehm & Basili, 2005; Bevan, 2009). Therefore, building a framework that can be used during the early stages of the design process has substantial additional value to learning solution developers.

Adding technology to classrooms can cause concerns for teachers due to e.g. conflicting or controversial results on the significance of digital games for learning. As the field of digital games is vast with the purposes, interaction types and content widely varied, it is impossible to make generalisations about the overall effectiveness of gamified learning (Sitzmann, 2011; Hanus & Fox, 2015). Moreover, research has indicated that when not enough concern is given to pedagogy and learning design in technology use, there may be negative repercussions on student learning outcomes (Vrasidas, 2015; Vermeulen, Kreijns, van Buuren, & van Acker, 2016). Concerns have also been raised about children's' screen-time in addition to the adverse effects of long-term technology use, which both impact negatively on health and school achievement levels of students (e.g. Genc, 2014).

While software and technological aspects of usability have long been a focus of study, there clearly is the need to understand the context of classroom and the interactions that occur within them to fully grasp what demands the context sets for design. Teacher beliefs have been shown to have an impact on their decision to integrate ICT into their classroom practices (Inan and Lowther, 2010). It has been suggested that teachers who have adopted a constructivist approach towards technology tend to be more active users of various technologies (Judson, 2006; Ertmer, Ottenbreit-Leftwich & Tondeur, 2015). As innovative practices may be shared among teachers who are flexible in their classroom ICT use, teachers with e.g. a more critical viewpoint to technology use in education may feel excluded from the discussion about the ICT choices made in their school (Stieler-Hunt & Jones, 2017). Error-welcoming pedagogies that support the flexibility of teachers' interaction and ICT use in classrooms are still more likely to be the endeavours of individual teachers than a widely accepted way of teaching (McWilliam, 2008; Kale & Goh, 2014). Many teachers still regard ICT use with caution or feel stressed by the change required from them to start using ICT more frequently or in different ways in their teaching, which may be amplified by the lack of support for such ICT integration efforts (e.g. Syvänen, Mäkiniemi, Syrjä, Heikkilä-Tammi & Viteli, 2016; Kenttälä & Kankaanranta, 2017). Research has found that there are several contributing reasons for technology related stress (technostress) of teachers. One of those reasons being the usability of technology (Al-Fudail & Mellar, 2008).

In this paper we present the results of an ongoing study, which aims at constructing a framework for the design of educational technology. The study continues cyclical efforts in the construction of the LETUS framework (see Kenttälä, Rousi and Kankaanranta, 2017). In this paper, the focus is on embedding contextual principles to the framework.

LETUS Design framework

There have been numerous attempts to model usability related issues and the usability design of educational software (Davids, Chikte & Halperin, 2014; Van Nuland & Rogers, 2015). Topics covered range from usability evaluation (Oztekin, Dursun, Ali & Selim, 2013), to understanding the structure and key properties of e-learning software in order to enhance learning outcomes (Squires and Preece, 1999; Van Nuland & Rogers, 2015), and incorporating insight into other key qualities such as fun (Read, 2008) and operationality in social media (Li et al., 2016) to name some. The knowledge gained from design and usability testing frameworks analysed for the LETUS framework (Kenttälä, Rousi & Kankaanranta, 2017) were categorised based on the technological pedagogical content knowledge (TPACK) model (Koehler and Mishra, 2009) to further their explanatory power. The focus of the TPACK model is on teacher knowledge, which complements the complexity of designing efficient learning software. It has been shown that higher TPACK levels reduce teachers' technostress (Joo, Lim & Kim, 2016). The utilisation of the TPACK model aims to ensure that all the necessary features teachers need to take into account when using technology in teaching would also be considered, while creating and analysing technology for their use.

The TPACK model comprises three main types of knowledge - technological knowledge (TK), content knowledge (CK) and pedagogical knowledge (PK) (Koehler & Mishra, 2009). Given the complex multi-layered nature of educational software, TPACK emphasizes the overlaps between and within the knowledge types to illustrate technological pedagogical knowledge (TPK), technological content knowledge (TCK) and pedagogical content knowledge (PCK), all of which should be accounted for when designing and developing software for learning (Koehler & Mishra, 2009). Furthermore, the model stresses consideration for the learning contexts and social aspects. Specifically, the knowledge aspect of the technology, content and pedagogy are important for this model, as it acknowledges that all three components require their own learning and skill development.

With this as a basis, the Learning Technology Usability (LETUS) Design framework focuses on furthering research and design knowledge on the usability of digital learning technology. The background research undertaken in the LETUS development, has produced a holistic framework for incorporating the complex array of usability evaluation features into designing a viable software product (Kenttälä, Rousi & Kankaanranta, 2017). The current study builds on the LETUS framework and further develops it to broaden the scope from analyzing existing learning technology towards designing pedagogically usable products that suit the context they are designed for.

Methods and Data

The work on the LETUS framework was carried out via two means: theory based fortification of the Learning, Content and Technology related aspects; and analysis of practice based articles for the contextual aspects of the framework. Work on the contextual aspects of the LETUS framework has been enhanced by analysing the use and definitions of the three levels of context (micro, meso and macro) in 14 articles. The articles were chosen based on Rosenberg and Koehler's (2015) previous work, which was through critical analysis of TPACK related research found to be the most comprehensive work on this topic. Rosenberg and Koehler focused on identifying levels of context present in each article, but not on what was being said about context on each of the three levels. This work expands on the knowledge gained from their research and through coding and analysing the individual representations of context in each article offers more insight on what are the aspects of context mentioned related to different levels.

From the concrete perspective of technical usability in the context of learning software, the software itself should require minimal learning, and rather, the concepts and content should be the pivotal nodes of concentration and challenge from the learner's perspective. To understand how previous research has accounted for these elements and more importantly dynamics between the elements and knowledge types, the LETUS framework has been formulated through the coding and analysis of data from 113 expert evaluation reports of nine different learning software products (see Mäkelä, 2015). The expert evaluations were conducted in seven countries. The resulting framework was formulated through integrating the categories derived from the data analysis with previous educational technology design frameworks. The original LETUS framework features four facets: learning, technology, content and context (table 1). These facets are expanded upon in the updated framework explained in the results section.

Table 1. Learning Experience Technology Usability (LETUS) framework components (Kenttälä, Rousi & Kankaanranta, 2017)

Learning	Content	Technology	Context
Feedback Guidance and instructions Concentration and attention Collaboration Assessment Confidence Motivation Skill development Previous knowledge Differentiation Skills for learning Creativity	Goals Authenticity and relevance Readability and literacy Concepts Multimedia	Flexibility Control Errors Consistency Aesthetics and trust Navigation and intuitiveness Communication Interaction Accessibility Scalability Reliability and maintainability	Satisfaction Immersion and flow Applicability Added value Sociocultural relevance

Results

In this section we will present results in two parts. The first part describes the revised dimensions of learning, content and technology. The second part describes the results from the analysis of earlier studies in regard contextual factors.

The fortified Learning Experience Technology Usability Design framework

The fortified Learning Experience Technology Usability (LETUS) design framework presented in this paper builds on the above mentioned (Table 1) framework introduced by Kenttälä, Rousi and Kankaanranta (2017), which connects theory to practice in the fields of education and usability research. In this paper, knowledge regarding this connection and the components of LETUS are deepened and steered towards specific design elements comprised in learning software. Understanding of the first three components of the LETUS framework: Learning, Content and Technology, was deepened through critical analysis of research related to each of the three aspects.

Learning is used in the Learning Experience Technology Design framework to indicate the learning process-related aspects of the software. Aspects such as feedback, guidance and instructions, collaboration, assessment and differentiation (Table 1) are just some of the elements that promote learning. These are the factors that teachers usually inertly do or promote to help learners in their learning process. However, in the context of learning software creation, these factors need to be given special consideration in regards to and on top of the other factors related to establishing a digital platform. Some of the most significant skills to be fostered include problem-solving, adaptability and critical thinking - skills, that with careful detail to design, are apt for learning in the type of environment that affords rapid information access, interactivity and simulation, as well as reactivity (Garrison, 2011; Lombardi, 2007).

The next category in the LETUS Design framework is Content. The content category features the combination of five components: Goals, authenticity and relevance, readability and literacy, concepts and multimedia. These components represent various aspects of the content which assist both in the experience of learning through the software, as well as the practical usability. Goals provide motivation in terms of comprehendible outcomes (Valle et al., 2003). Authenticity and integrity of the content in relation to the content providers, their subject or field experience and the accuracy of the content provided, is reinforced by the relevance of the material to support the learning goals. Readability relates to the visual clarity of the text, font and size, in addition to the amount of text supplied and the language through which it is expressed. Literacy is supported through the readability, yet also entails factors such as a match between the levels, abilities and language of the reader (UNESCO, 2006). Concepts and their usage connect with literacy, and the understandability of these concepts is facilitated through contextualization and explanation, relevance and even demonstration as afforded by devices such as multimedia.

Technology design in the LETUS Design framework consists of eleven components (Table 1) that address the basic requirements for a usable software product. From the 21st century skills perspective, flexibility of use can be considered a key feature in the design of digital learning software (Garrison, 2011; Lombardi, 2007). Flexibility of use allows the users to also take control of their own learning, which is one of the essential concepts of these modern learning theories. Avoiding error prone conditions and providing users clear ways to recover from errors are important also in learning software design. Communication within and through the use of learning technology is one key component in supporting a communicative approach to learning. Aesthetics and trust relate to the visual aspects of the learning software that should both be aesthetically pleasing and build trust in the user through e.g. consistency. Accessibility should be taken into account in early stages of software development to allow a wide variety of users to access the software without significant hindrances. Ways to interact with the learning software should be fluent and coherent. In the current multi-device use environment it is important to give scalability proper consideration, since e.g. online learning environments may be used on varied devices (e.g. mobile devices and laptops). One key requirement for software to be usable is its reliability and maintainability. When creating software that is not intended for a single use, but for continued use it is important to make sure that maintenance and modifications to the contents or e.g. upgrades to the software are easy to make.

Contextual aspects

Context related aspects of learning technology have in the past been defined in various ways and levels of detail. Here, the TPACK model was used as the basis for the categorisation in the earlier version of the LETUS framework. Even though articles related to the TPACK model generally talks about context as an important part of the model, it is usually addressed ambiguously and is commonly not clearly defined (Kelly, 2010; Porras-Hernández & Salinas-Amescua, 2013). In their article Porras-Hernández and Salinas-Amescua created a conceptual model for analysing contextual factors on micro (classroom or learning environment factors), meso (learning environments outside the classroom) and macro (societal factors that affect teachers and learners e.g. national curriculum) level. This model was later further elaborated by Rosenberg and Koehler (2015) and this model has been used to further the knowledge about contextual factors in the LETUS Design model.

Context as defined in the previously formed LETUS framework includes five factors: satisfaction, immersion and flow, applicability, added value and sociocultural relevance (Table 1). These broad categories include key issues related to assessing the usability of a learning technology in relation to the context it will be used in. The work is expanded in this study by analysing how context has been defined in research of educational technology use and specifically in TPACK model related research. Through this analysis the context in the LETUS framework has been modified to better match the intricate nature and complexity of context in the use of learning technology. The current model considers the concept of context on the three levels defined by Porras-Hernández and Salinas-Amescua (2013): micro, meso and macro (figure 1).

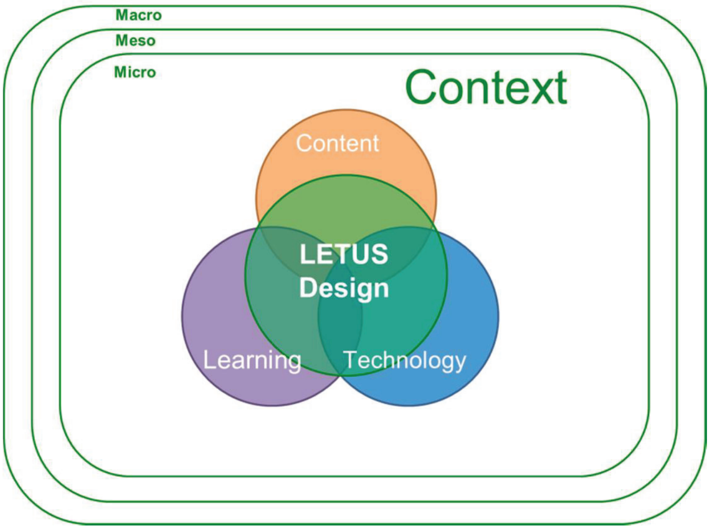

Figure 1. LETUS Design framework with division of different levels of context

Through the analysis of altogether 14 articles in the data, it was discovered that micro level contextual aspects had been defined in all of the 14 articles, meso level in 10 and macro level in 8 research articles. These defined aspects from each article were then further analysed in relation to the LETUS framework to increase the explanatory power of the contextual portion of the framework.

On the micro level, 11 individual factors affecting the micro level context were found from articles (Table 2). Micro level factors cover four domains: physical, social, content and knowledge and skills-based factors that influence the use of ICT in classrooms for learners and teachers. Physical context in these studies focused on both the constraints and affordances offered by ICT. Social factors related to safety, collaboration in the classroom and beliefs. Content factors included subject, content, age level suitability and authenticity of the materials. Knowledge and skills based factors covered ICT competencies and teacher classroom strategies. Out of all the micro level contextual factors, those that were subject-related were discussed the most in the original articles, with 10 out 14 articles focusing on this aspect of context in relation to the TPACK model.

Meso level factors were addressed in 10 out of the 14 articles analysed for this study (Table 2). There were five meso level factors identified from the articles: Online courses, Teacher training, Experience based knowledge, Informal learning and non-educational contexts and Collaboration outside the classroom. Online courses were seen as one way teachers gained more TPACK related knowledge and skills. Teacher training and the style of teaching the teachers had themselves received were mentioned as a contextual factor that influences technology use in the classroom, in 5 out of 10 articles that had defined meso level factors. Experience based knowledge the teachers had accumulated was also considered as one aspect that influences their technology decisions. Two out of the fourteen articles also raised informal learning opportunities such as video games and electronic books. Lastly, collaboration outside the classroom such as on- and offline peer groups were considered to be parts of the meso level context factors affecting teachers' technology decisions and use.

On the macro level there were eight factors identified from the 8 articles that described macro level contextual factors (table 2). Firstly, there were three theoretically based factors identified: models and frameworks, theory and research knowledge and adaptation of models to suit the context. On the school level, factors such as school values, teaching practices and the overall infrastructure of the school were seen as having an effect on teachers technology use in classrooms. In the wider context also curricula (local and national) and cultural and economic background were considered to influence contextual factors relevant to teachers classroom practices.

Table 2. Contextual factors in analysed TPACK articles

Context		
Micro (classroom or learning environment factors)	**Meso (learning environments outside the classroom)**	**Macro (societal factors that affect teachers and learners)**
Subject / discipline Age level Content area Emotional and social environment Skills and competencies Affordances Authenticity Collaboration and knowledge transfer Beliefs and tacit knowledge Constraints Teacher classroom strategies	Online courses Teacher training Experience based knowledge Informal learning and non-educational contexts Collaboration outside classroom	Models and frameworks Curricula Theory and research knowledge School values and expectations Teaching practices and pedagogy Adapting models to context Cultural and economic context Infrastructure

These findings from the three context levels (micro, meso and macro) were used to fortify the structure and content of the LETUS framework. The framework (Table 1) was reorganised to better suit the understanding gained from researching contextual factors from 14 TPACK articles and to fortify the understanding the contextual intricacies and complexities relevant to designing learning software. Context is seen as a category that adheres to all other aspects (learning, technology and content) of the framework. Context as it now understood in the LETUS Design framework can be seen as a combination of four context types in three levels of context (Table 3). Context types include individual, social, environmental and content. These four types of context are utilised as a further categorisation to understand what types of contextual features affect the design of learning technology. The further divide to three context levels support understanding of both the immediate and further aspects of TPACK that affect classroom use of learning technology and should therefore be integral parts also in the design process.

Table 3. Contextualisation matrix of the LETUS Design framework

LETUS Design framework aspect	Context type	Micro	Meso	Macro
Learning	Individual	ICT skills Learner related Beliefs Tacit knowledge Age level Teacher (classroom) strategies Competencies Expectations (satisfaction)	Experience based knowledge	Teaching practices and pedagogy
	Social	Collaboration and knowledge transfer Communication and interaction Emotional and social environment	Collaboration outside classroom (e.g. mentors)	Cultural and economic context School values and expectations Curricula
Technology	Environmental	Physical environment Constraints (e.g. availability of technology) Affordances (technology and contextual) Immersion and flow	Online courses Informal learning and non-educational contexts (e.g. video games)	Infrastructure
Content	Content	Content area Structure and organisation of content Authenticity Activity type specific Subject / discipline	Teacher training	Theory and research knowledge Models and frameworks Adapting models to context

Aspects associated with context in the previous version of the framework (table 1) have been incorporated also into the revised LETUS Design framework. Out of the five features three, Satisfaction (as expectations), Sociocultural relevance (as Cultural and economic context) and Immersion and flow, have been included in the contextualization matrix (Table 3) and the other two, Applicability and Added value, have been dissolved. The latter two aspects upon further analysis were seen as compounds of features from each category being influenced by feature from all three levels of context. Therefore they have not been included as separate factors into any specific category of the current matrix as they are broader categories incorporating several of the other factors.

Conclusion

The focus of this paper was to present added insights and research based reiteration of the LETUS framework, intended to aid in the design and evaluation of learning software products and services. Through drawing on a background of previous learning software usability-related research, the ideas and development of LETUS Design framework were illustrated. Significant developments in the model's life course were explained through detailing related literature and theories that not only account for the origins of LETUS Design framework, but demonstrate the differences in conceptual understandings and applications. Through understanding the context teachers use technology in additional design considerations can be given to develop learning software that not only enables the product to be used in the context, but also supports teachers who might still feel reluctant to integrate technology to their teaching by providing them with solutions that are built for their needs.

The reinforced LETUS Design framework gives a greater understanding of the contextual aspects that affect all learning technology but have not been defined to a satisfactory degree in relation learning technology design. This work adds to the research in the field of usability and learning software design and evaluation to offer deeper understanding of the complicated issue of context. However, practical and empirical validation of the current framework needs to be concluded and as such the framework's contribution to current knowledge is mainly theoretical. Also, the current framework may require adaptation and further elaboration of features to be used in practical settings through instrumentalization of individual design aspects. Even though all aspects presented in the framework are relevant to learning software they are not necessarily all the criteria that learning software needs to include. The definition of the set of basic requirements for different types of learning technology requires more research and testing.

The LETUS Design framework enhances the understanding of formal educational context and classroom practices to teachers and learners in schools. The indirect benefit of such efforts are gained by teachers and learners alike who are increasingly able to access learning technology that better suits their needs and context. The framework could benefit teachers and learners more directly, as teachers can also gain understandings of the complex nature of contextual knowledge that affects their technology choices and use. As such, the framework could be further developed to additionally suit the needs of teachers looking for learning solutions in order to suit their context. This is due to the fact that LETUS Design framework highlights the key considerations related to learning technology directly in relation to use context.

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IV

COURAGE TO LEARN AND UTILIZE ICT IN TEACHING - BUILDING UNDERSTANDING OF TEACHERS WHO LACK COURAGE

by

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Courage to learn and utilize ICT in teaching - building understanding of teachers who lack courage

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Abstract: Innovative use of information and communication technology in education is a topic that has received a lot of attention both in public and academic debate. Innovative practices have been communicated and visions for sharing them have been around for years, however, the large scale adoption of such practices has not yet been achieved. While highlighting and sharing best practices may be an inherently positively motivated attempt, teachers enthusiastically explaining their innovative ICT practices may be met with even resentful attitudes from colleagues. Discussion focusing on praising innovative ICT teaching practices as good ideals may leave those teachers whose current teaching isn't up to this standard out of the debate. This paper aims to further the understanding of teachers who currently lack courage to try new ICT approaches in their teaching and how they could be supported in finding ICT practices that they are able to flexibly utilize in their teaching.

Introduction

Recent research efforts have been aimed towards understanding digitally innovative teachers and finding out how their enthusiasm and practices are being met and how these could be applied on a larger scale in schools. Thus, a lot of focus has been given to teachers who utilize innovative ICT practices in their teaching. During all the hype surrounding these so called early adopters of technology, the teachers currently using ICT in smaller scale in their teaching are often given negative attention and feedback in regards their ICT teaching practices. Also, the terms related to this group of teachers may have negative connotations such as *'Unbeliever colleagues'*, while innovative teachers are associated with more positive terms e.g. *'Lone believer'* (Stieler-Hunt & Jones, 2017). However, instead of focus on transferring innovative practices to other teachers, the question why all teachers are not adopting innovative practices has more seldom been asked.

According to Dweck (2012) the main difference between these two teacher groups can be observed in their mindsets. Those teachers with innovative practices commonly share a *'growth mindset'* and their focus is on finding ways to learn instead of focusing on how to teach (Dweck, 2012). The teachers with more traditional views may share *'closed mindset'* where errors and failure are not seen as opportunities to learn but as something to avoid. Mainstream pedagogy has not adopted error-welcoming pedagogies, which are utilized mainly by individual teachers (McWilliam, 2008). McWilliam (2008) elaborates that adopting this pedagogical view requires the ability to be at times uncomfortable and ignorant, which may be hard to teachers accustomed to strong control of teaching situations.

Inan and Lowther (2010) found out that teacher's beliefs strongly affected their use of ICT and the level of integration of ICT into classroom practice. In more traditional views, teaching can be seen as public exchange of knowledge to an audience of students, who learn from what their teachers offers them (Routarinne, 2007; McWilliam, 2008). The role of sole authority, instead of co-creator of knowledge, may cause stress related to chaos and losing control of what happens in the classroom (McWilliam, 2008). Sharing ICT teaching responsibility as is often suggested with more ICT savvy students, so called digital natives (e.g. Prensky, 2001; Helsper & Eynon, 2010), may not be a source of assurance but a challenge to the assumed status that is expected of teachers in traditional teacher centered views still affecting many ICT teaching practice (Kale & Goh, 2014).

Teachers with student-centered views on learning tend to lose control of learning and those with teacher centered views tend to assert strong control over learning and may even fear the loss of control. To cope with this stress Routarinne (2007) explains teachers may start to limit their teaching practices and create routines of using teaching practices that have previously proved effective. As Kahneman (2012) explains when we as humans are faced where we feel threatened our actions may not be entirely conscious, due to unconscious priority being given to self-protective actions. Even slight fear and anxiety about failing may create demands and restrictions on thinking, which in turn limit the freedom, creativity, spontaneity and ability to create new (Routarinne, 2007).

At best on core level meaningful use of digital learning materials and games is focused on improving students learning processes and outcomes. Teachers are more likely to use ICT in a meaningful way, when it matches their pedagogy (Kale & Goh, 2014). Also there is indication that increasing general ICT use may have even negative effect on student academic achievement, if enough attention wasn't given to pedagogy and learning design related to ICT use (Vrasidas, 2015). Schools may also have set core organizational goals for use of ICT in education, however, individual teacher practices may not always be supportive of achieving these organizational level goals (Vermeulen, Krejins, van Buuren and van Acker, 2016; Hamari & Nousiainen, 2015; Leithwood and Jantzi, 2006). Tondeur, van Braak, Ertmer and Ottenbreit-Leftwich (2017) suggest that teacher beliefs about what is good education is a critical dimension in professional development programs for supporting meaningful use of technology for learning and teaching purposes.

Teacher attitudes towards using e.g. digital games in their teaching may still be influenced by views of games interfering with student's education instead of benefitting their education (Hodges & Prater, 2014). If digital games are seen as ineffective tools for learning teachers may not attempt or are not successfully able to find suitable links between games, curriculum and class context (Stieler-Hunt & Jones, 2017; Chee, Mehrotra & Ong, 2015; Hodges & Prater, 2014). However, as Stieler-Hunt and Jones (2017) point out the problem is more complex than simple alignment of games with curriculum, as their study indicated teachers were also among other things scare of losing control when using games in classroom.

Nardi and O'Day (1999) suggest that the basic problem in regards technology use is not in the overall use, but in making conscious choices in technology selection and ways of use. Why would teachers attempt to overcome their own insecurities and fears towards ICT use in their teaching, if they don't see value of it in relation to their students' learning? Vermeulen et al. (2016) found that intellectual stimulation of teachers in transformational leadership was the only variable to show positive effect on teacher perceived norms. Vermeulen et al. (2016) found that perceived norm had the weakest and attitude had a strong relation to intention to use ICT in teaching. Teachers attitude has also been suggested by other research (e.g. Kim, Kim, Lee, Spector & DeMeester, 2013) to be a key factor in teachers integration of ICT into their teaching.

Previous research has shown some indication (e.g. Badia, Meneses, Sigalés & Fàbregues, 2014) that teachers own use of ICT reflects on how they use ICT in student learning. Office software and word processing software in particular has been seen as a necessary prerequisite to basic ICT use in education. It has been suggested that teachers, who don't use simple office software such as word processing software (Hsu, 2011) only occasionally assign ICT-related activities to their students. Hsu (2011) suggests that teachers require certain level of proficiency with each particular tool to use the tool to enhance student learning.

This paper aims to shed light on those teachers who lack the necessary courage to try new (ICT related) approaches. The paper attempts to find out, what are the qualities and skills of those teachers who are not yet flexible and courageous experimenters in using ICT in their teaching. Thus the paper aims at building understanding of such teachers' current ICT-related teaching practices and skills as well as their needs for professional development. By doing this, we try to find more beneficial approaches towards closing the ICT related practice gap among teachers.

Research design

The data was collected through an online survey. Survey respondents included 151 in-service teachers from school levels ranging from preschool to upper secondary school in Central Finland (Kenttälä, Kankaanranta & Neittaanmäki, 2017). The main focus of this study was on primary and lower secondary school teachers, but some of the teachers participating in the study worked simultaneously in lower and upper secondary schools or in primary and preschool education.

The survey questionnaire was designed based on survey instruments in two earlier studies, namely Second Information Technology in Education Study (SITES; Kankaanranta & Puhakka, 2008; Law, Pelgrum & Plomp, 2008) and Finnish Teaching Technology in Education Study (Kankaanranta, Palonen, Kejonen & Ärje, 2011). Some additional survey items in regards teachers view on digital learning material and school where formulated based on the Speak Up Survey (Smith & Evans, 2010). The teacher survey consisted of 27 survey items that related to 4 main content themes: *'Current ICT habits and practices'*, *'Support for ICT use'*, *'Skills and ICT professional development'* and *'Curriculum and digital school'*. In combination of the background information this study takes a closer look at all relevant survey items from the four content themes to create understanding of the teachers who lack courage to try new approaches.

Subgroup of teachers for this study was selected based on their answers to a question dealing with their perceived ICT use barriers. More specifically, from this multiple choice question one statement *'I don't have the necessary courage to try new approaches alone'* was chosen for a closer study. When addressing the issue of ICT use barriers for teachers, one interesting observation is related to teachers' self-belief of their courage to use new ICT related approaches alone. Out of 151 teachers participating in the ICT survey 74 % assessed that they have courage to try new approaches alone. However, 26 % indicated that they didn't have enough courage. This paper focuses on these 26 % and aims to map out whether these teachers share other qualities and what are the issues related to the ICT related support they receive.

The main focus is on building understanding of the shared and individual characteristic of the teachers who indicate they lack courage in implementing new approaches. Some preliminary comparisons will be made with the group of teachers, who indicate they have courage to try new ICT approaches.

Results

The results section of this study is divided into four parts. Firstly, the background section addresses the subgroup of teachers lacking courage and elaborates on the basic age distribution, teaching experience and teaching disciplines within in this subgroup. Secondly, the use of ICT section takes a closer look at how this group of teachers themselves utilizes ICT and how their students use ICT in class. Thirdly, the issue of teachers perceived barriers to ICT use are further analyzed. Lastly, attention is given to the expressed support and professional development needs of teachers lacking courage to use ICT.

Teachers' background

Teachers lacking courage were predominantly female (79 %) and most commonly 50 - 59 years old (51 %). Other larger age groups were 30–39 (21 %) and 40–49 (21 %) years. Out of all the survey participants fitting in the age group 50-59 years 40 % belonged to the group who lacked courage. In other age groups the portion of teachers lacking courage was under 30 %. The teachers were mainly experienced teachers with more than 10 years of teaching experience (82 %). More than half (56 %) of teachers belonging to this group had more than 19 years of teaching experience. The group consisted of mainly primary school and subject teachers, who didn't teach ICT as a separate subject.

ICT proficiency and practices

There were several types of ICT tools and software that teachers used in their education at least occasionally (Figure 1). Half of the teachers lacking courage used messaging tools, practical equipment and mobile devices often in their teaching. Multimedia tools and interactive whiteboards were only categories where more than 49 % of teachers said they don't utilize it at all in their teaching. Other ICT related equipment and software were utilized at least occasionally by almost two thirds of the teachers lacking courage. On the whole teachers lacking courage and those having courage shared similar practices in what type of equipment and software they commonly use in teaching.

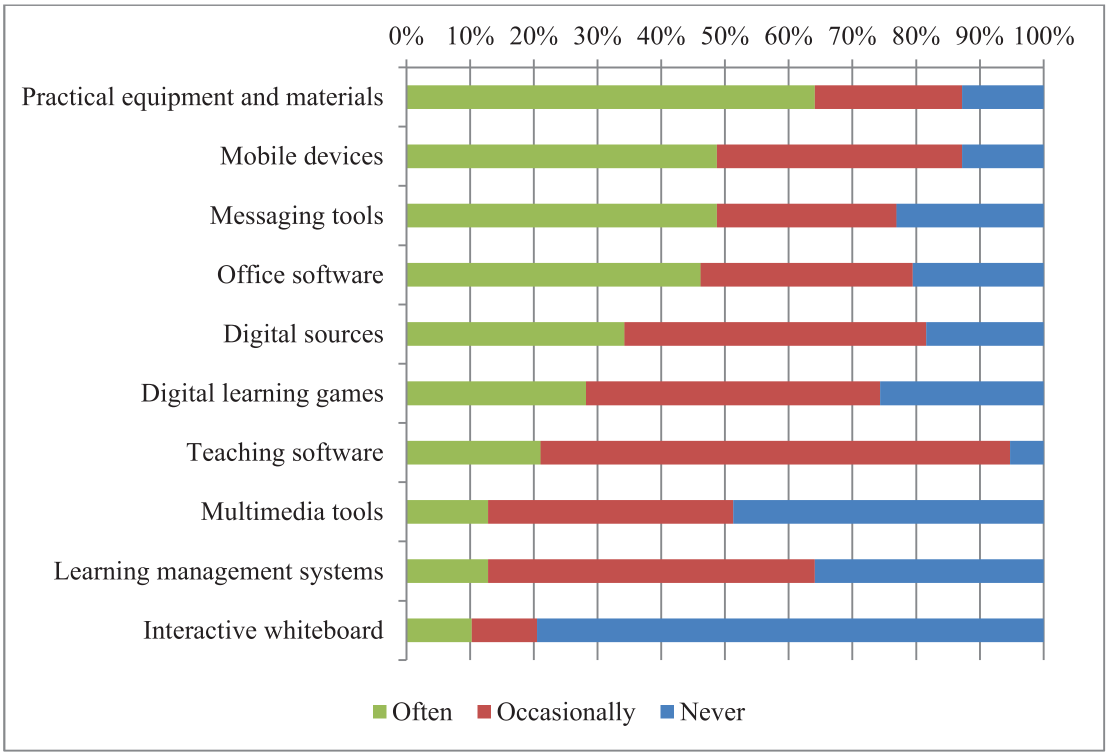

Figure 1: The ICT equipment and software most commonly utilized by teachers lacking courage

Teachers assessed their own proficiency in several ICT software categories and tasks (Figure 2). Teachers who lack courage claimed most proficiency in using social media and office software, as more than half of them indicated that they could use them at least reasonably well. Almost all of the teachers (95 %) lacking courage believed that they knew at least to some extent what kind of teaching and learning situations the use of ICT was suitable. However, generally speaking the group lacking courage did have a more timid view of their current knowledge about the situations where ICT use was suitable than their peers who have courage. None of the teachers lacking courage claimed excellent mastery in this aspect, while 35 % of the teachers with courage were confident of their capability to evaluate the appropriate situations where to apply ICT in teaching and learning.

Teaching coding and computational thinking is one of individual new core skill sets that were added to the Finnish national curriculum in 2016. As this survey was conducted before the new curriculum were adopted in schools it indicates the level of teaching proficiency prior to actual mandatory teaching of computational thinking in schools. Teaching coding and computational thinking on the whole is seen by teachers as something that most of the teachers lacking courage had no proficiency at all (82 %).

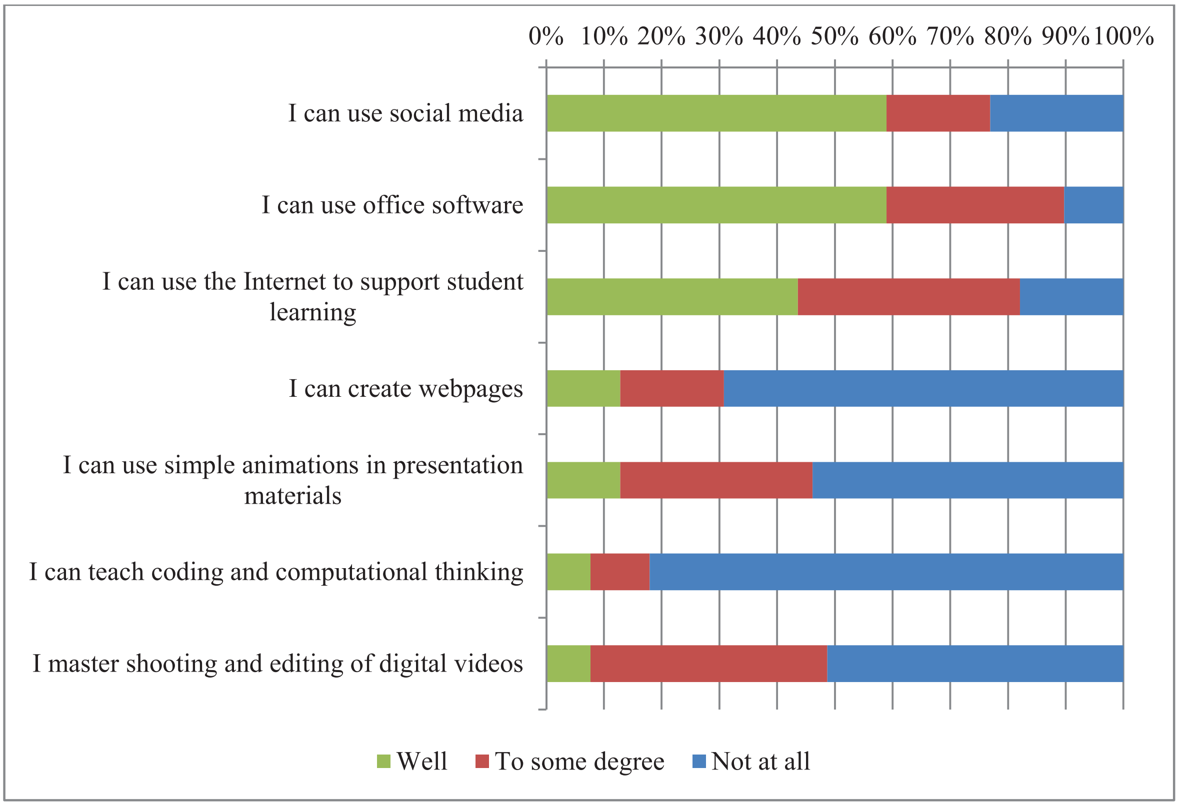

Figure 2: Teachers who lack courage perceived proficiency in ICT related tasks and use of ICT equipment

When analyzing how pupils use ICT during lessons clear indications in both teacher groups can be found towards a traditional strategies in pupils' ICT use. In both groups, it can be observed that use of ICT for students' to reflect on their learning, to complete self or peer evaluations or express their own ideas are tasks teachers seldom assign for their students. Also tests or other evaluations of pupils learning through the use of ICT aren't very common practice that teachers adopt with their pupils. ICT is most commonly used for independent self-paced learning, doing exercises, working with same materials with other pupils and giving presentations. These results show that there are some indications towards communicative learning strategies, but also indication that tasks related to deep learning skills such as reflection are not something that pupils often have the chance to do during lessons.

Although the general trend in student tasks show tendency towards traditional uses of ICT for learning purposes, some teachers lacking courage explained practically oriented but rather innovative ICT practices when asked about their most positive experience with ICT use with students. One teacher lacking courage named as their most positive experience using tablets for delayed video feedback and another using tablets in measuring friction. Using mobile devices such as tablets seemed to generally be the chosen equipment for more innovative ICT practices among teachers lacking courage.

Barriers of educational ICT use

Overall teachers lacking courage see several barriers in using ICT in their teaching (Figure 3). Most commonly they assessed that they lack time resources (87 %), ICT related pedagogical skills (79 %) and general ICT skills (77%). Among teachers who have courage the same barriers can be seen, but less than half (<-45%) of the teachers in this group assess that these are barriers in their use of ICT. Furthermore determining what technological equipment in useful for their teaching was seen as a barrier by more than half of the teachers. Teachers also identified that they had a need for professional development courses, but that the required course was either generally not offered or their school didn't necessary resources to offer it.

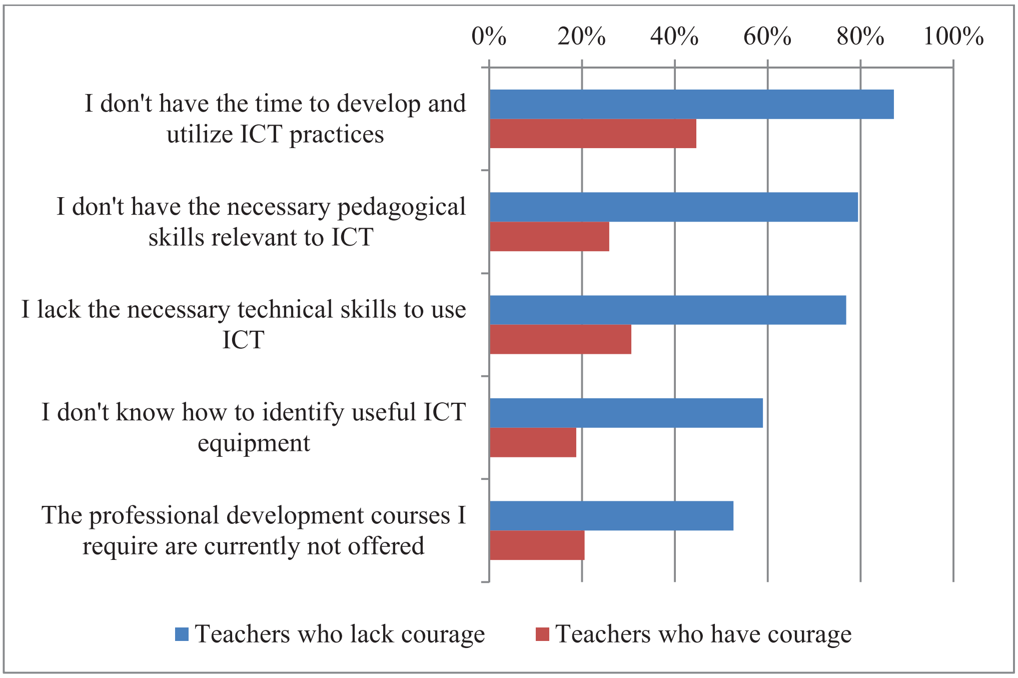

Figure 3: Teacher perceived barriers in using ICT for teaching and learning purposes

Professional development and support

According to the majority of teachers (83 %) the preferred way of organizing professional development were courses held at their own school. The level of participation on ICT professional development courses was relatively low in all course types (Figure 4). Introductory courses to basic and office software were the most common courses that teachers (23 %) had already participated in. When looking at the professional development needs of teachers it can be observed that majority of them expressed a desire to participate in several ICT related professional development courses, but are not currently able to do so. The type of professional development teachers expressed most interest towards related to pedagogically oriented course for integrating ICT in teaching and learning (79 %). On the other end of the spectrum courses related to technical maintenance and use computers was something over half (64 %) had not participated and had no interest in participating even, if the opportunity would be offered.

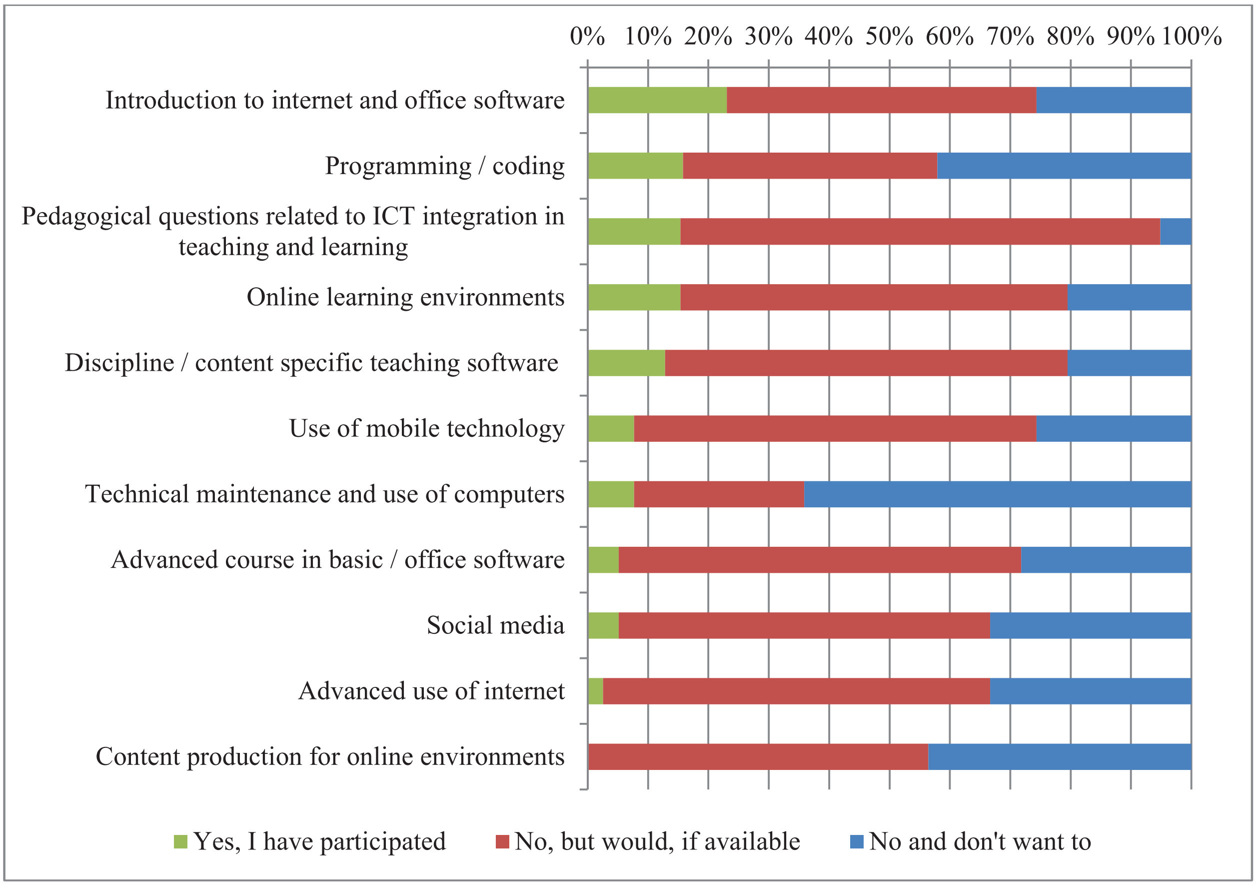

Figure 4: Professional development of teachers lacking courage

In addition to professional development needs teachers were asked to assess whether, if needed they receive enough technical support for their teaching (Figure 5). Almost two thirds of the teachers lacking courage also responded that they don’t receive enough support when they need it. In the group of teachers that have courage more than two thirds of teachers assessed that they receive enough technical support for their teaching.

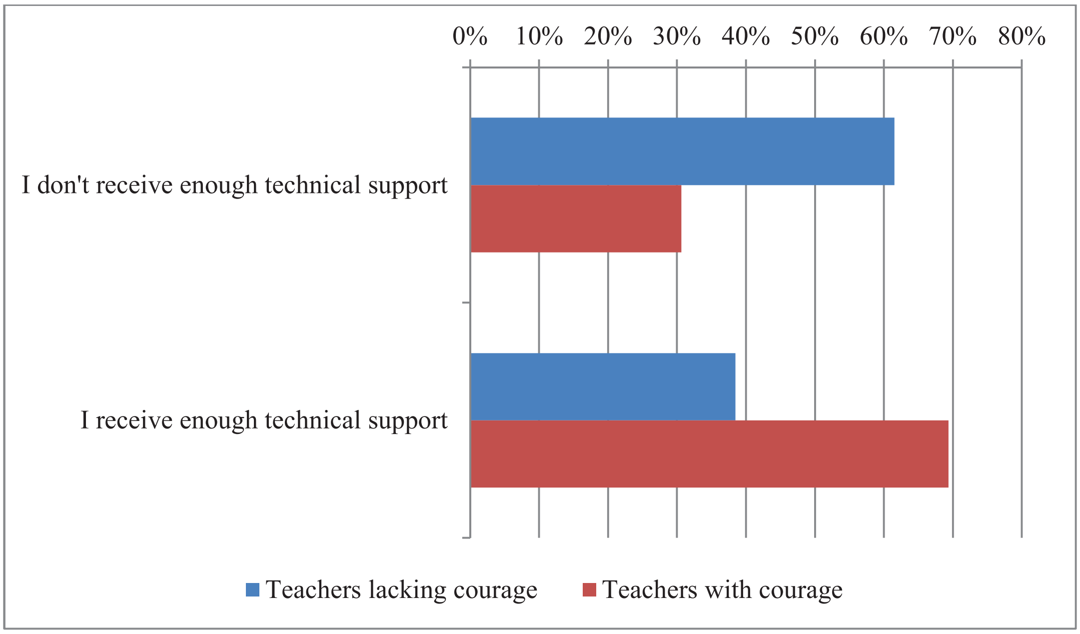

Figure 5: Current access to technical support during teaching

Discussion

As teachers are challenged to use digital technology in their everyday teaching practices, there is also a rise in more critical voices that question this need for constant change. As Nardi & O'Day (1999) suggest as long as sufficient knowledge about technology is a prerequisite for taking part in discussion about its use, a broader and joint dialogue is challenging to emerge. In order for the discussion around technology to free itself of the almost religion like rhetoric of '*lone believers'* and *'unbelievers*' in regards ICT a more neutral stance towards those whose current ICT use doesn't match the supposed ideal, might be necessary. Removing the stigma from using old pedagogy with ICT in teaching is a necessary first step towards giving voice to those that need it the most. As McWilliam (2008, p. 266) puts it "*not knowing need to be put to work without shame or bluster"*.

> *"As long as we think we do not have enough expertise to engage in substantive discussions about technology, we are effectively prevented from having an impact on the directions it may take. [...] We believe that the lack of broad participation in conversations about technology seriously impoverishes the ways technologies are brought into our everyday lives." (Nardi & O'Day, 1999, 13)*

While understanding and learning from best practices of current innovators in teaching is valuable, it may on the other hand place shame and stigma on those who are not yet achieving this set ideal in their teaching. Sharing of innovative ICT practices with great passion may even create a divide between teachers in the same school and start a cycle of resentment towards the teachers with innovative ICT practices (Stieler-Hunt & Jones, 2017). Stieler-Hunt and Jones (2017) suggest that even though hardware and software limitations may still be relevant barriers in teacher ICT use, addressing these barriers will only be effective when the underlying cultural and political issues are also addressed.

Teachers lacking courage to try new approaches have both individual and to some extent shared characteristics in regards of their current skills and views of ICT use in teaching and learning. Generally speaking teachers belonging to this group share somehow negative outlook on their ability to use ICT in more complex tasks. They perceive several barriers in their ICT use and their own proficiency in using ICT in teaching and learning. Also they feel that they don't always receive the technical support they require during classes, which in turn may inhibit their use of ICT in their teaching.

Previous research has suggested that teachers who don't use office software (e.g. word processing) also rarely assigned ICT related tasks to their students (Hsu, 2011). In this study 21 % of the teachers lacking courage said they never use office software in their teaching. However, most of these teachers despite not using office software in their teaching did assign several types of ICT related tasks for their students at least occasionally. Only one teacher not using office software did not assign any ICT related tasks for students.

Some positive indication was shown that the chosen ICT equipment may produce more innovative ICT practices also in teachers lacking courage. Traditional computers may in part lead to creation of more traditional learning tasks for students and mobile devices may through their affordances also spark the creation of more innovative student assignments. The physical availability of technological tool is not sufficient to ensure their use in education (Vrasidas, 2015). More attention should be given to the affordances of technology to assess what they bring to teaching and learning (Vrasidas, 2015).

Supporting and empowering teachers who currently lack courage to try new approaches is a demanding task. Although some characteristics are shared, this is a heterogeneous group of teachers with different backgrounds and needs in regards using ICT in their teaching. Deeper analysis of the needs and ICT related characteristics of the group of teachers lacking courage is required to understand the most suitable ways of supporting their individual support needs. The current work is a preliminary view on the group of teachers lacking courage but further research is required to find the shared and dissimilarities between teachers who lack and who have courage. Deeper analysis of their mindsets and pedagogical beliefs affecting their ICT practices are necessary to create better support and professional development practices that raise teacher's self-efficacy in using ICT.

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