Learning Experience Technology Usability Design framework

Veera Kenttälä
Rebekah Rousi
Marja Kankaanranta
Faculty of Information Technology, University of Jyväskylä
Finland
veera.kenttala@jyu.fi
rebekah.rousi@jyu.fi
marja.kankaanranta@jyu.fi

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about learning and pedagogy, and more specifically their contexts, will lead to creating learning software that utilize outdated pedagogy or are lacking in critical aspects of pedagogical design.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).

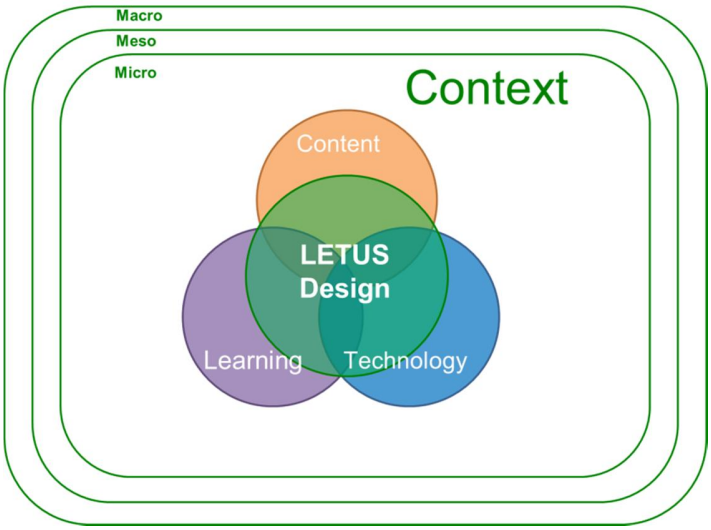

Figure 1. LETUS Design framework with division of different levels of context

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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