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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-

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
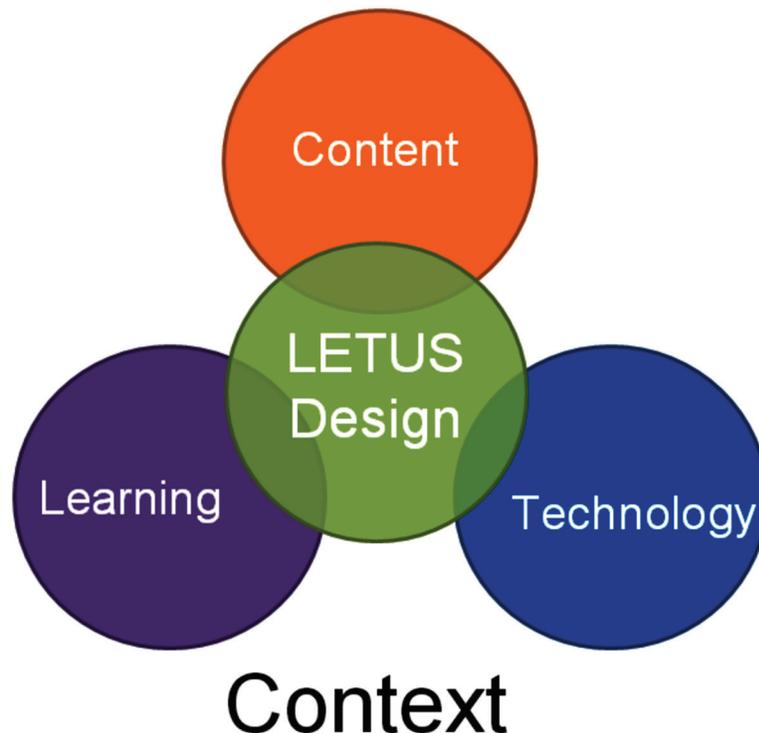
Table 3. Combined features from individual frameworks

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.