TOWARDS USABILITY INTEGRATION INTO E-LEARNING DESIGN
Lietojamības integrācija e-apmācībā

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Abstract. *While e-learning use has sharply increased, the drop-out rate is high. This paper addresses some of the aspects that cause users to reject e-learning and not finish. It focuses on the concept of "usability", especially pedagogical usability that is currently central to usability design. While the term is nebulous, it is identified by attributes such as learnability, efficiency and (subjective) satisfaction. Attributes can be measured and designers add new ones as the need arises. Satisfaction has become the focus of pedagogical usability experts who claim the term includes motivational and emotive factors and may be measured by psychometric testing. Currently, efforts are underway to integrate pedagogical usability into e-learning design and create attractive, flexible features that are easy to handle and available on demand. Efforts are also underway to design mobile learning that incorporates usability principles. Usability improvements have been incremental because the e-learning process is not clear to designers, but it is expected that awareness and innovations will correct this problem in the future.*
Keywords: *Usability, Pedagogical usability, (subjective) Satisfaction, Affective Attributes (factors), holistic approach, Human Computer Interaction (HCI), Ergonomics.*

What is Usability and why is there problem?

E-learning programs are becoming increasingly popular in higher educational institutions as well as businesses and other organizations. Even elite universities such as MIT, Harvard and Cambridge are part of this trend and are offering e-courses online. The reasons for this trend are not hard to find: e-learning is accessible, versatile, and economical, may be offered anytime, anyplace and is not geographically bound (Miller, 2005). Moreover, with the growing trend of older adults returning to school, the popularity of lifelong learning and the ongoing job training needs of business and other organizations the demand is predicted to continue. Yet the dropout rate for e-learning programs is high—much higher than in traditional face-to face classes; some researchers put the figure as high as 80% (Panagiotis and Polymenakou, 2009, 76). Researchers find this trend a serious concern and quite rightly argue that the drop-out phenomenon needs in-depth investigation if e-learning programs are to succeed and satisfy users.

Initially, e-learning programs were developed by technocrats interested in designing technically functional e-learning programs rather than pedagogical usability tools. Moreover, it was hoped that as technology advanced the usability issue would take care of itself. This, however, has not been the result, and more and more e-learning designers who are also pedagogues argue that usability, especially pedagogical usability must be directly addressed and planned for to produce satisfactory e-learning programs. (Kukulska-Hulme and Shield, 2004) Yet progress in this direction has been slow. In part this trend reflects still existing technological

limitations, but also a certain conservative mind-set among software developers. Their focus has been effectiveness and efficiency of technological operability, not user satisfaction. As Mark Notess and others have observed, user satisfaction and usability puts technocrats outside their comfort zones, and they have often put the blame on the technical incompetence of users rather than usability deficiencies of the software. (Notess, 2001; Michael J.Miller, 2005). Additionally, decisions about upgrading e-learning programs often reflect cost-cutting business measures. Many e-learning programs are off-the-shelf commercial solutions and even when they claim to offer innovations one or two issues may be addressed while the essential program remains the same. (Kukulska-Hulme, 2007) Therefore, it is not really surprising that users have often rejected these technological learning products and voted with their feet. Yet there is a growing consensus among IT professionals, researchers and pedagogues that e-learning programs must actively engage users if this method is to succeed as a pedagogical learning tool and convince more users to stay the full e-learning curriculum; therefore, the issue of usability has become central in defining new directions in e-learning design. Usability needs to be planned for and integrated into the design process right from the start. It cannot later be applied like a thick layer of peanut butter to cover-over poorly designed applications. (Nielsen, 1993; 16)

Usability Attributes

Usability is central to ergonomics that tries to fit office technology to the needs of workers (and not the other way around). Ergonomics has become of great concern to many international organizations, including the International Organization for Standards (ISO) (Nielsen, 1993; 227). As early as 1991, ISO recognized the need for ergonomic regulation of computers that were increasingly becoming a part of office equipment. In the directive of the same year entitled *Ergonomic requirements for office work with visual display terminals VDTs,* ISO issued guidelines for human computer interactions. (ISO 1991) The title of the document was eventually simplified to *Ergonomics of Human System Interaction* as it is known today. ISO identified usability as the central concern of ergonomics and defined it as follows: "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," and the organization has expanded upon this definition in subsequent directives (ISO 9241-11 1998). In ISO/IEC 9126-1 (2001), ISO increased usability attributes to five: understandability, learnability, operability, attractiveness, and usability compliance (Alonso-Rios et al, 54 (2010). The computer engineer Jakob Nielsen, a leading usability expert specializing in HCI (Human Computer Interaction) and ergonomics has done much to map-out the attributes of usability. He identified usability as consisting of: learnability, efficiency, memorability, low error rate or easy error recovery, and satisfaction. Learnability–originally coined by Nielsen, was recognized by ISO as authoritative (Nielsen, 1993 -26; Jeng, 2005-48) Nielsen's and ISO's attributes are considered

as basic and usability experts have expanded upon them to meet the needs of their specialties and to describe technological innovations.

Usability does *not* have one, over-arching definition; it is identified by attributes (Nielsen, 1993; 26). The advantage of identifying usability attributes is that they may be measured and tested. Analyses of Nielsen's basic terms reveal the level of user engagement and achievements. **Learnability**, the most basic attribute measures not only the expert but the novice, how long does it take the beginner to gain a working level of proficiency; **efficiency**, how quickly and how easily may the user complete tasks; **memorability**, can the novice or causal user easily recall recently learned operations and tasks; **easy error recovery**, how easily and quickly do users recover from errors; catastrophic errors indicates there is serious trouble and serious design and technological problems; (subjective) **satisfaction**, does the user exhibit satisfaction and enjoyment in completing tasks. (Nielsen, 1993; 26).

It is important to analyze user satisfaction in some depth because their positive attitudes towards e-products attract consumers, whether the products are commercial or educational much as Apple has done with its e-products and has shown how users may take satisfaction in and even identify with technology. Moreover, the most recent e-learning trend has been to expand upon the concept of user satisfaction to include emotional factors that affect users' motivation and ability to learn including, interest, boredom and anxiety (possibly feeling confused and fearful about the technology) (Panagiotis and Polymenakou, 2009; 76). Zaharias Panagiotis, a computer expert in Human Computer Interaction (HCI), and his colleagues have made user / learner motivation the focus of their studies. They argue that there is a strong correlation between user motivation and usability (Zaharias and Polymenakou, 2009; 89). They view successful learning as directly related to affective behaviors (emotional issues) that have more in common with pedagogical methods and values than as operational, functional technological events (*Ibid.,* 76). Therefore, they maintain:

> … usability practitioners need to familiarize themselves with the educational testing research, learning styles, and the rudiments of learning theory. It seems that there is an ellipsis of research validated usability evaluation methods that address the user as a learner in a holistic way, which includes the consideration of cognitive and affective learning factors.

Achieving satisfaction in learning is an important aspect of pedagogic usability because it indicates that a user is totally absorbed in the learning tasks and feels competent in their execution so that a rhythmic pattern is achieved that carries the user on to the next task, suggesting Mihaly Csikszentmihalyi's flow theory of learning (1975). This is the learning ideal to which technology at this point can only aspire to.

Pedagogical Usability

One of the foremost exponents of how technology can teach us to learn is Tom Reeves who added a pedagogical dimension to computer based education

[usability]. Inspired by the ideas of Seymour Parpert, an early advocate of the computer as a teaching tool and constructivist idea–an educational theory that claims that knowledge is socially and individually constructed on the basis of experience–Reeves has actively promoted a generative learning environment that is ergonomically supported and is perceived as a quality learning experience. (Reeves 1998) Reeves and his colleagues have argued that e-learning design was not simply an offshoot of computer technology but was more related to pedagogy whose methodology and approaches e-learning design needed to incorporate to be successful (Reeves et al., 2002; 2). He has mapped out the new field Computer Based Education (CBE) that he regards as based on fourteen pedagogical dimensions, each of which incorporates some aspect of learning theory or learning concept. It is a constructivist theory where individuals learn by doing, learn through discovery and from their mistakes. It is part individual, part social. Reeves claims it represents "anchored instruction" that is context and situation driven and not abstract without practical application that he believe traditional learning tends to be. The goal of constructivist education is knowledge generation—to encourage users to create their own knowledge (Reeves, 1998). Part of the "construction" of new knowledge involves electronic "mindtools" such as hypertext, multimedia, "HyperCard" (from Apple) (HyperCard was discontinued by Apple in 2004. It was an early example of a plug-in. It has been replaced by web based design tools such as HTTP, JavaScript and authoring tools, but there are still many clones on the market, like SuperCard, HyperNext, and HyperStudio. "HyperCard," *Wikipedia* http://en.wikipedia.org/wiki/HyperCard (accessed 21 Feb 2012)) and spreadsheets. (Reeves, 1998) These methods also encourage collaborative learning. An amalgam of constructivism and "situated learning" (context driven) is "socioconstructivism" that may be the next learning theory. (Adito et al., 2005; 272)

Pedagogical usability is now a key influence on designers of e-learning software; but how people actually learn WITH computers—still presents a problem today. Pedagogy requires flexibility and dynamism and it has proven to be a real challenge for designers. It is not understood how social factors, pedagogical factors, psychological factors and other factors motivate users to interact with computer learning. How these factors impact upon interface design still needs to be evaluated. (Kukulska-Hulme and Shield, 2004). Recent studies have focused on the need to restructure technological design to be compatible with users' needs and satisfaction and deliver content that is more in line with pedagogical practice. But these studies recognize, the adjustments to pedagogical approaches can only be incremental—as they have been all along, but now they are more planned and focused-- as designers and developers become aware of users' needs through feedback and integrate the findings into learning design.

Tools for Usability Design

Authoring tools are among the most basic features of e-learning course design. David Griffiths and his colleagues are hard at work in simplifying this tool to make more usable for all levels of users. Griffiths describe his experience with

designing web-based authoring tools and the limitations of current programming languages that leaves many users unsatisfied; instead he adopted IMS LD, a highly sophisticated programming language. Reload Learning Design Editor and its successor, ReCourse can be used to author learning designs in this framework (Griffiths et al., 2009; 201). IMS LD can operate in the Open Source Eclipse system with plug-ins (Griffiths et al., 2009; 208). To develop its own framework for the program would be far too complex and demanding for a web based program. Yet by following an iteration process, he and his associates arrived at ways to simplify the authoring tool so that users at all levels could apply it. It is boon for the expert and Griffiths and his colleagues have tried to make adjustments for novices and intermediate level users. ReCourse features default files where less experienced users when completing a learning activity can simply click on edit and the relevant resources of that activity will automatically become part of that file. Experienced users have wider access to the system, can edit their own files, and have a wide selection of resources they wish to add to their files. (Griffiths et al 2009, 213) Griffiths and his colleagues champion the program, not only for its flexibility and creativity, but also because it highly adaptable to the learning format and supports a whole range of pedagogic requirements that can be delivered online. It also appears well matched with e-learning specifications. While the program in its present form is still daunting for the average user, the authors feel they have succeeded in simplifying many of the steps and have added usability features for the general public to be able to successfully apply. (Griffiths et al., 2009; 219).

Mobile Learning: the new frontier of pedagogical usability

Mobile learning is the new learning frontier. In tandem with computer-based learning, it has proven to be a capable assistant. Full course m-learning delivery, however, does not exist at this point although rapid technological advances may make this option available in the near future. Mobile learning is attractive because it adds a ubiquitous dimension to e-learning that allows it to take place anyplace and anytime and also greatly expands communications and collaborative potential. While its potential is clearly perceived, it is still a digital application on the brink. Its chief role is that of a digital assistant for computer based e-learning or traditional face-to-face instruction. However, as a teaching tool to support more recognized forms of learning, it has produced some interesting results and achieved notable successes. (Majumder, 2010) Mobile devices are effective as personalized learning support tools to assist users with certain aspects of their professions. The material uploaded in the mobile may be individualized to suit the users' needs and interests and is available at anytime when the need arises. (Majumder, 2010; 27). Moreover, students enjoy mobile devices and regard them as part of the necessary gear of the digital age. Yet interestingly, some students resist mobile devices as learning tools and regard them as part of recreation. They also fear mobile learning may be expensive, but with the dropping of mobile calling rates this fear may be set aside perhaps at a not a distant future. (Suki and Suki, 2011; 50).

Because of the increasing popularity of mobile learning portals, efforts have been made to systematize mobile learning usability principles similar to the attributes developed by Nielsen. The most comprehensive effort in this regard has been by Daniel Su Kuen Seong whose article "Usability Guidelines for Designing Mobile Learning Portals" (2006) provides ten guidelines (he does not refer to them as attributes because he feels more study must be made in order to identify them) to focus on when designing courses for mobile learning. The underlying concepts are usability and motivation, because, as Su points out, unless these concepts are the basis of the design, users will probably not be attracted to the learning program. He especially addresses issues such as small screen display by recommending that long text be broken up into small segmented chunks that fit small screens. (Su, 2006; 3) Su also thinks that scrolling should be kept to a minimum. As a preferred navigation method, he recommends menu hierarchies from which users may select desired items. Su feels this method has merit because it is extending a function that users are already familiar with. (Su, 2006; 4) While Su's guidelines are only suggestions at this point and mobile usability principles are still very much in flux, he has mapped out ground-work for developing usability attributes for mobile learning. Usability is an issue that m-learning designers need to identify and focus on if m-learning is to succeed as a learning approach.

Some promising experiments have been conducted testing mobile learning to enhance traditional forms. In a recent experiment at a technological university in Malaysia, computer scientists developed a platform independent mobile learning tool that was designed according to ADDIE (ADDIE is an instructional design model based on five steps. Development consists of continuous prototyping and feedback that sets up the next step in the sequence. http://www.learning-theories.com/addie-model.html (accessed 21 Feb. 2012)) guidelines for the primary purpose of testing usability principles for mobile learning delivery. The primary principles for which this tool was tested were: effectiveness, learnability, memorability, and user satisfaction—an amalgam of Nielsen's and ISO's usability attributes (Sahilu et al., 2011; 1310). In the experiment there were a total of 120 participants, all drawn from the engineering faculty. The participants were divided into two groups, each consisting of 60 students; the control group, and the test group. The control group was taught by strictly conventional methods (the article does not specify what these consisted of); while for the test group, the conventional learning was enhanced with the mobile learning tool. The participants in both groups were given a pre-test and post-test after the learning was completed. It was found that the participants in both groups scored about the same on the pre-test, but that on the post-test there noticeable differences. In factors involving memorability (memory) and learnability (criteria not defined), the test group did better; however, on issues involving content and well as understanding, the conventional group did better. (Sahilu et al., 2011; 1317-18). The researchers observed that the results may reflect the limitations of mobile learning at this point; its limited storage and inability to engage with complex cognitive issues in depth. Yet the authors felt that the outcome was impressive and showed the mobile learning not only had a place,

but also a future that would come with rapid technological developments and that would improve learning performance. (Sahilu et al., 2011; 1319) The conclusion that this reader draws from these result is that as a study-aid the mobile phone performs remarkably at this time, but as a tool for deeper cognitive development it is deficient. However, as Sahilu et all indicate, technological development may meet this challenge in the future and correct this problem.

Agnes Kukulska-Hulme, the mobile learning expert from Open University, sums up the current state of mobile learning. She argues that mobile learning design is an innovative undertaking; but that its future success will depend upon how effectively human factors (ergonomics) are integrated into the new technology. (Kukulska-Hulme, 2007). Her article is a discussion of mobile usability and how it could be more effectively integrated into m-learning. One of the major issues she regards as too many mobile devices on the market, each one slightly different with most mobiles having a life cycle of 12 months or less. Because the interface of mobiles differs with each manufacturer as do the applications, it is difficult to design learning materials for these devices. Kukulska-Hulme preference is for PDAs for which more standardized software applications suitable for m-learning could be designed. She notes that users often lack an understanding of how the PDAs may be used, but when instructed are quite happy about the variety of functions a PDA may perform including downloading academic articles, applying multi-media or brainstorming with colleagues. Yet she also notes that it is not always possible to predict how users will apply mobile functions and that users sometimes find creative uses for functions that designers had not imagined, but may in fact offer new uses and solutions. She points out that a number of guidelines have been published for producing m-learning products and that the best way to arrive at useable mobile learning design is to track m-learning over a longer period of time to update guidelines in light of more knowledge and experience. Her observations on mobile learning at this time may be summarized as being multifaceted but quirky, but also dynamic and evolving. (Kukulska-Hulme, 2007; 7).

Usability Testing and Evaluation

Usability testing should be done soon and often, and from the results modifications can be made that are more ergonomically orientated. Hostile interfaces are to be avoided, a result that can be accomplished by repeated testing. Iteration is the most fundamental principle of e-learning design for creating attractive and functionally usable products that are also pedagogically effective learning tools. (Nielsen, 1993; 16, 21)

The testing methods of usability include observation, scenarios (scenarios are “stories” that may be computer based or appear on a storyboard. They are projections of situations, equipment or software design that they test. They differ from modeling in that they do not take into account the entire project but address only a specific situation or equipment), automated logging of user activities, heuristic evaluations (usually by experts, but also experienced testers), thinking

aloud, and constructive interaction, especially suitable for public schools pupils who often exhibit problems in following directions and whose performance seems to improve in group activities. Retrospective testing with video film may be another approach if certain problems / issues warrant replay and re-think. User interviews and questionnaires are important evaluation methods and are especially appropriate for measuring user satisfaction. They need careful planning in design and execution and should be developed for all stages of a project development. Heuristics is one of the cheapest testing methods and therefore most often employed although feedback from users provide insight in usability issues.

The type of usability aspects that lend themselves to measurement are: the time users need to complete tasks, how many tasks users may complete within a given timeframe, the ratio between errors and successful executions, the time and ease with which the user recovered from errors, how many commands and menu items users were able to utilize, "dead-time" when users are not interacting with the system. To determine what is going on—is the system defective, is the user thinking, or is the user frustrated—is the task for the examiner to evaluate and then address these issues accordingly (Nielsen, 1993; 192ff).

Panagiotis and Polymenakou applied a psychometric-type questionnaire based on educational testing methodologies. The questionnaire was developed in five stages: (1) creating the survey, based on related studies and / or experience; (2) Sampling (3) two pilot testing sessions (4) working draft; (5) final version. It was intended to test the reliability and validity of the measuring instrument and by iteration adapting it to the group being tested (Panagiotis and Polymenakou, 2009), 79). The authors recommended adopting a motivationally based questionnaire to test subjects for the usability of learning applications and tools and how effectively they engage learners and motivate them. Finally, the authors caution further study of their method, because, as they note, construct validity—or when practice matches theory-- cannot be claimed from a single study but from a number of interrelated studies. (Panagiotis and Polymenakou, 2009; 89)

A highly detailed usability questionnaire was designed by Petri Nokelainen, a specialist in educational methodology, for elementary school children (Nokelainen, 2006; 178). Pedagogical usability was the focus of his study. The questionnaire that was developed was really a self-evaluation that Nokelainen regards as appropriate for evaluating subjective factors, such as pedagogic usability. The emphasis of the questionnaire was on the user: his / her control over the course and material and his /her expressions of engagement in the course. (Nokelainen, 2006; 189) The questions were direct to elicit direct answers. Some samples questions were: *I am proud of my own solution, or one that I made with others, to the problem presented in the learning material. (Definition: I feel that I or we together, have made something that is significant.); this learning material adjusts the difficulty to suit my skills. (Definition: I can practice something that is hard for me until I have learned it and before I move on to the next topic.)* (Nokelainen, 2006; 194-195) The results indicated that a Pedagogically Meaningful Learning Questionnaire (PMLQ) had been designed that it had been able to capture

the pedagogical usability profiles of the learning modules. It also showed that the learning materials had added a cross-disciplinary (Nokelainen does say "multidisciplinary," but cross-disciplinary seems to me more appropriate because it means borrowing methods from two or more disciplines, which in fact is what happens here. The new terms for multidisciplinary is interdisciplinary where one discipline is built from a number of other disciplines, as for example "American Studies" or "Women's Studies". But the terms are close (Nokelainen, 2006); 190)) approach to the study of computer science and education and had moved e-leaning towards a more holistic, human centered methodology. Nokelainen, however, warns that the sample was small and the learner group too restricted (elementary pupils) to be able to draw definitive conclusions about it. He recommends further study with different test groups to confirm validity and reliability of the questionnaire and its ability to capture usability profiles (Nokelainen; 2006; 189-190).

At present there are three main methods of usability evaluation: (1) Inspection or Heuristics usually by experts, but also by experienced experimenters (2) User based evaluations, usually questionnaires. Ardito et al have added a third category, (3) scaffolded criteria of abstract tasks (ATs) that address the technological aspects of e-learning design such as operability and functionality. (Ardito et al., 2006; 278, 281-282). Ardito and his colleagues refer to this method as Systematic Usability Evaluation (SUE). Systematic evaluation of e-learning software at present does not exist. Various usability experts have contributed a variety of methods that are of diverse quality. The evaluation methods above, however, most often appear in the literature, and have been user tested by diverse groups. When employed on an ongoing basis, they allow designers, pedagogues and experts to keep usability in focus as the e-products develop.

Conclusion

Usability has become a fundamental issue of e-learning development taking its direction from ergonomics and HCI requirements. Its scope has greatly increased over the last decade. It is only recently, however, that researchers have begun to perceive that e-learning is really a pedagogy and that technical developments need to support a dynamic, interactive learning environment. This awareness has focused researchers' attention on ergonomic issues such as subjective satisfaction, motivation, affective attributes and pedagogic usability. It has been a challenge, however, to bring technological developments in line with subjective and motivational issues.

Pedagogical usability is now a key influence on e-designers; but how people actually learn WITH computer is still not understood. Reeves and his colleagues have accepted the challenge and promoted Computer Based Education (CBE) that has been described as "socioconstructionism", a learning theory based on fourteen pedagogical dimensions. It is part social, part individual where users create online learning communities and construct knowledge based on their pedagogical and social experiences applying the currently available "mindtools." Really flexible

and dynamic software systems do not at this point exist, but developers are at least focusing on the problem and are hard at work in creating more dynamic learning tools. Most likely the solutions will be arrived at by incrementally. Griffiths and his associates are at work in creating a dynamic authoring tool that they hope to simplify and make available on the web. They also feel that the expressive, flexible features of the software would be suitable to the interactive, dynamic scenarios that are suitable for pedagogic environments. Right now, however, it remains a tool for experts—although the designers are at work to achieve ever more simplified models.

Mobile learning as well offers the potential of a ubiquitous learning approach that makes it a useful application anytime, anyplace. In a support capacity m-learning provides excellent assistance to traditional e-learning. But at this point m-learning does not offer full course delivery. Some of the problems are concerned with technological insufficiencies such as limited memory and storage capacity, as well as lack of standardized parts or inadequately developed mobile infrastructures systems of some nations. Costs as well can be obstacles to students on limited budgets. Designers and experts, however, are hard at work in overcoming these obstacles and may offer a dynamic approach to m-learning that is attractive and affordable to users in the near future.

As with much of e-learning design, there is no defined testing and evaluation method and designers have at times developed methods of diverse quality. At present there are basically two: heuristics (by experts or experienced testers) and user evaluations most often by interviews and questionnaires. The first is the cheapest and fastest; the second is time consuming and requires much planning—yet user feedback is essential for the success of a project. Iteration is the basis of successful e-learning design; its results give direction to project development. Repeated and often is the rule of thumb because even when not perfect, some feedback is better than no feedback. At present e-technology cannot match the dynamic, interactive requirements of pedagogical usability. Yet designers and producers are focused on the issue and may in the near future offer innovations that will bring comprehensive, integrated e-learning systems that offer flexibility, ease of handling and choice.

Future work consists in analyzing usability as applied to online communities. More comprehensive and integrated systems are also currently being developed, not only with mobiles and web-based programs—some of which were discussed in this paper–but also television, internet and mobiles. How effective these projects are, how “useable”, how ergonomically sound, will need to be analyzed by future research as these projects develop. DESC at RTU is currently developing the EU regional project eBig3 that integrates television, internet and mobiles into a comprehensive learning system. Its ergonomic effectiveness will only be demonstrated with repeated iterations in the course of the project development. "Synergetic approach with eLearning, TV and mobile technologies to promote new business developments –“eBig3" (Contract) Nr. LLIII-183).

Bibliography

1. Alonso-Ríos, D., Vázquez-García, A., Mosqueira-Rey, E., Moret-Bonillo, V., (2010). Usability: A Critical Analysis and a Taxonomy. *International Journal for Human Computer Interaction,* 26(1), 53–74.
2. Ardito, C., Costabile, M.F., De Marsico, M., Lanzilotti, R., Levialdi, S., Roselli, T., Rossano, V. (2006). An Approach to Usability evaluation of e-Learning Applications. *Universal Access Info. Society* (Springer) (2006) 4: 270-283.
3. Concannon, F.A.F.;Campbell, M. (2005). What campus-based students think about the quality and benefits of e-learning. *British Journal of Educational Technology* 36(no. 3), 501-512
4. Granic, A.; Cukusic, M. (2011). Usability Testing and Expert Inspections Complemented by Educational Evaluation: A Case Study of an e-Learning Platform. *Educational Technology & Society*, *14* (2), 107–123.
5. Griffiths, D.; Beauvoir, P.; Liber, O.; Barrett-Baxendale, M. (2009). From Reload to ReCourse: learning from IMS Learning Design implementations, *Distance Education: Routledge*, 30(August, no.2), 201-222.
6. Faiola, A. and Sorin A.M. (2010). Enhancing human-computer interaction design education: teaching affordance design for emerging mobile devices. *International Journal of Technology and Design Education (2010) (Springer) 20: 239-254.*
7. International Organization for Standardization (ISO) (1998). 9241: Software Ergonomics Requirements for office work with visual display terminal (VDT), Geneva, Switzerland
8. Jeng, J., (2005). "What is Usability in the Context of the Digital Library and How Can It Be Measured? *Information Technology and Libraries. June, 2005,* 75-99.
9. Koole, M., McQuilkin, Janice, L.; Mohamed, A. (2010). Mobile Learning in Distance Education: Utility or Futility? " (2010) *Journal of Distance Education 24(no. 2): 59-82.*
10. Kukulska-Hulme, A. (2007). Mobile Usability in Educational Contexts:What have we learnt?" *The International Review of Research in Open and Distance Learning (IRRODL)*, June 2007 http://www.irrodl.org/index.php/irrodl/article/view/356/879
11. Kukulska-Hulme, A.; Shield, L. (2004). The Keyes to Usability in e-Learning Websites. *Proceedings of the Fourth International Conference of Networked Learning 2004*, Lancaster, UK.
12. Miller, M.J. (2005). *Usability in E-Learning, ASTD's Sources for E-Learning* http://www.astd.org/LC/2005/ (accessed 6 Oct. 2011)
13. Majumder, M.; Pramatha Nath Basu. (2010). Usability Study of Personalized Learning in Mobile Learning Environment," *International Journal of Interactive Mobile Teachnologies (iJIM)* (2010) 4(3): 25-29 http://www.doaj.org/doaj?func=abstract&id=560253
14. Nielsen, J. (2005). Ten Usability Heuristics http://www.useit.com/papers/heuristic/heuristic_list.html (accessed 12 October 2011)
15. Nielsen, J. (1993). *Usability Engineering*: San Francisco: Academic Press.
16. Nokelainen, P. (2006). An Empirical Assessment of Pedagogical Usability Criteria for Digital Learning Material with Elementary School Students. *Educational Technology and Society* 9(2) 178-197.
17. Notess, M. (2001). Tutorial: Usability, User Experience and Learner Experience, *e-Learning Magazine, No*8, August 2001, 3. http://elearnmag.acm.org/archive.cfm?aid=566938 (accessed 6 Oct. 2011)
18. Paechter, M.; Maier, B. (2010). Online or face-to-face? Students' experiences and preferences in e-learning *Internet and Higher Education* 13 (2010) 292–297.

19. Panagiotis, Z.; Polymenakou, A. (2009). Developing a Usability Evaluation Method for e-Learning Applications: Beyond functional Usability. *International Journal for Human Computer Interaction,* 25(1), 75-98. 76.
20. Paternò, F.; Russino, A.; Santor C. (2007). *Remote Evaluation of Mobile Applications*. Lecture Notes in Computer Science (Springer) (2007): 155-168.
21. Reeves, Thomas, C. (1998). *Evaluating what Really Matters in Computer-Based Education*. http://www.eduworks.com/Documents/Workshops/EdMedia1998/docs/reeves.html (accessed 10-02-2012)
22. Reeves, Thomas, C.; Benson, L.; Elliott, D.; Grant, M.; Holschuh, D.; Kim B.; Kim, H.; Lauber, E.; Lob, S. (2002). Usability and Instructional Design Heuristics for e-Learning Evaluation. *World Conference on Educational Multimedia, Hypermedia and Telecommunications*, Proceedings (14th Denver, Colorado, June 24-29, 2002 (available from ERIC).
23. Sahilu Wendeson, Sahilu. Development and Usability Evaluation of Platform Independent Mobile Learning Tool," *World Academy of Science, Engineering and Technology* (80): 1310-1321.
24. Suki, Norazah Mohd; Norbyah Mohd Suki (2011). Using mobile device for learning: from students' perspective. *US-China Education Review* A 1 (2011): 33-53. (ERIC).

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