Handbook of Research on Innovative Pedagogies and Technologies for Online Learning in Higher Education

Phu Vu
University of Nebraska at Kearney, USA

Scott Fredrickson
University of Nebraska at Kearney, USA

Carl Moore
University of DC, USA

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Chapter 18
Evaluation Methods for E-Learning Applications in Terms of User Satisfaction and Interface Usability

Nouzha Harrati
University of Souk Ahras, Algeria

Zohra Mahfouf
University of Souk Ahras, Algeria

Imed Bouchrika
University of Souk Ahras, Algeria

Ammar Ladjailia
University of Souk Ahras, Algeria

ABSTRACT

The use of online technology has become ubiquitous and integral part of our daily life from education to entertainment. Because of the ubiquity of e-learning and vital influence for engineering the educational process, it is no surprise that many research studies are conducted to explore different aspects covering the use of e-learning in higher education. The assessment and evaluation aspects are considered arguably the most influential part for measuring the success and effectiveness of e-learning experience. As more and more universities worldwide have opted to use online technology for their course delivery, research in e-learning systems have attracted considerable interest in order to apprehend how effective and usable e-learning systems in terms of principles related to human computer interaction.

INTRODUCTION

In a modern society, the use of online technology has become ubiquitous and integral part of our daily life from education to entertainment. This is mainly due to the proliferation of the use of computers and smart devices combined with the availability and affordance of internet connectivity in most places. In fact, digital networks and modern communication have greatly transformed and reshaped the way we live and work in such a contemporary era yielding a tremendous effect on the necessity and opportunity to learn (Garrison, 2011). Although, there are advocates in the academic community who prefer traditional teaching methods which include face-to-face communication, considerable efforts are being devoted

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to promoting e-learning and the use of new technology for course delivery and teaching. The learning paradigm is shifting from lecturer-centered to student-centered as it can be undertaken anywhere, from classrooms to homes. In fact, several scholars described the growth rate of e-learning as unprecedented and explosive as the adoption of e-learning went beyond academic institutions to be considered seriously in corporate companies and public administrations as part of their employee training programs. Because of the ubiquity of e-learning and vital influence for engineering the educational process, it is no surprise that many research studies are conducted to explore different aspects covering the use of e-learning in higher education. This includes for instance the learning models, software interactivity and human behaviors. The assessment and evaluation aspects are considered arguably the most influential part for measuring the success and effectiveness of e-learning experience (Anderson, 2008). Evaluation for e-learning goes beyond assessing the learner performance. The evaluation of the delivery procedure for e-learning is as critically important to understand and harvest a meaningful and fruitful learning experience (Granić, 2008; Harrati, Bouchrika, Tari, & Ladjailia, 2016). In fact, considerable criticism regarding the quality of existing e-learning systems are being cited by a number of studies (Chua & Dyson, 2004) in addition to further issues including low performance, poor usability and customizability. Furthermore, online education has been further criticized as not supporting a student-centred learning but replicating the traditional face-to-face teaching paradigm.

For the definition of e-learning, although the term can be simply explained as an educational software system that allows a user to learn anywhere and at any time, an agreed definition for e-learning is still elusive among scholars (Moore, Dickson-Deane, & Galyen, 2011). The term of e-learning starts with the letter e which stands conventionally for electronic in the same way as e-mail. The term "online learning" is occasionally used to refer synonymously to e-learning in which case the learning process takes place away from formal classrooms and facilitated by the use of internet-based technologies. The terms e-learning and online learning can vaguely overlap with other terms such as distance learning which is often associated with older technologies (Moore et al., 2011; Pachler & Daly, 2011). Horton (2011) defined e-learning as the practice of using information and communication technology (ICT) to simulate a learning experience that can be created, organized and managed with enough freedom decoupled from any temporal or geographical boundaries. Triacca et al. (Triacca, Bolchini, Botturi, & Inversini, 2004) argued that certain level of interactivity needs to be included to render the definition applicable for describing the learning experience. Pachler and Daly believes that the primary aspect in the debate for the elusive definition of the term seems to be around which specific pedagogical model needs to be designed and integrated within the use of digital and online technology. Pachler et al. further stressed that e-learning is no longer about the distance or remote learning, but forms part of a modern paradigm and conscious choice in education for the best and most appropriate ways of promoting effective teaching. The Joint Information Systems Committee (JICS) which is an influential organization within the United Kingdom supporting higher education institutions in the implementation and adoption of new technologies, referred to e-learning as "enhanced learning" with the definition of "learning facilitated and supported through the use of information and communications technology". Blended Learning is another term which is frequently used and it tends to point to the teaching process where computer-based learning are integrated in tandem with face-to-face classical teaching activities (Garrison & Kanuka, 2004). This is known as a hybrid form of e-learning in which online technologies are employed to enhance or supplement traditional teaching (Garrison, 2011). Flipped classroom is a pedagogical form of blended learning where typical lecture and homework of a course are reversed. Lectures are viewed

by students at home via distance education before the class session, while in-class time is dedicated to exercises and discussions.

In addition to the use of e-learning in academic institutions for acquiring knowledge, one of the other important goals of e-learning is to develop professional skills and understanding in the corporate world to help employees accomplish their career objectives (Colvin Clark & Mayer, 2008). In the commercial place, e-learning is synonymous with both terms: Computer-Based Training (CBT) and Web-Based Training (WBT) in which they do refer to the delivery of training courses and materials through the use of computers or web technology. Meanwhile, the term tends to point to a mode of study within the university context in which physical presence in not required inside a classroom. Semantically, it is vital to understand and differentiate between the terms; learning and training as they are inextricably linked and have common aspects within the educational process. The term training is the act of giving instructions, knowledge or information through voice, written words or other communicative methods of demonstration with a fashion that instructs the trainee. Meanwhile, learning refers to the process of absorbing the information in order to enrich and increase skills and abilities that can make use of it for various contexts (Garrison, 2011).

Importance and Benefits

Because of the vital importance for the use of online technology as a medium for distance or virtual education, corporations and schools are investing substantially large amount of money, time and resources in developing alternatives to traditional methods of education and training. In the corporate side, employees ought to be kept up-to-date with the latest information and knowledge in a very competitive business world. Various companies have kept pace in adopting e-learning solutions for their corporate training such as CISCO e-Learning and Dell Learning (Wang, Wang, & Shee, 2007). The global e-learning market has witnessed a remarkable growth to exceed hundreds of billions of US dollars based on a recent report by Global Industry Analysts (Chuo, Liu, & Tsai, 2015) with millions of students are enrolling for web-based courses (Wirt et al., 2005). The annual growth rates in technology-based learning are expected at 27% for the next several years. For a contemporary era where technological and educational modernization are shaping and redefining the standards of education, e-learning is considered the converging point to such evolution. Because of the importance for e-learning which evolved greatly under the rapid advancement of internet technology, the US Web-based Education Commission published the following statement:

The question is no longer if the Internet can be used to transform learning in new and powerful ways. The Commission has found that it can. The Web-based Education Commission calls upon the new Congress and Administration to embrace an 'e-learning' agenda as a centerpiece of our nation's federal education policy.

The statement given by the commission for the development and innovation program recommends further that embracing the e-learning should be accompanied with a deeper understanding of how students learn, how technological tools support, assist and assess learning gains and more importantly what is required to keep the pace of e-learning moving positively forward.

As technology has progressed so much that geographical gap is virtually bridged with the deployment of tools that make people collaborate and interact together remotely with the feeling that they are inside the same room. The use of e-Learning in schools and corporations gained popularity mainly due

to the perceived advantages of flexibility around fitting the students' time requirements and overcoming the issue around the geographical restrictions. The time aspect is one of the issues that instructors and learners both have to deal with in learning or tutoring sessions. In the case of traditional face-to-face teaching, the arrangement of time can be restrictive for the attendance to a certain group of students who have the ability and availability to attend at a specific time. Along with the timing restrictions, travelling and being present at the location where the learning would take place can be a major obstacle. On the other hand, e-learning offers the benefits to facilitate the learning process without having to worry about when or where every learner can be available and present to attend the course. In other words, e-learning provides the students with the capability to accommodate learning and training around their busy lifestyles, granting effectively the opportunity even to the busiest person to pursue further their career to earn new qualifications. In a study published by (Welsh, Wanberg, Brown, & Simmering, 2003), the authors reported that organizations can accomplish numerous benefits from implementing e-learning programs, including consistency in training, reduced cycle time and cost, better convenience for learners and improved tracking capabilities. Zhang and Nunamaker (2003) suggest that effective and efficient computer-based training methods are in great demand by the industry to ensure that employees and partners are equipped with the most advanced skills. In the same way, academics and practitioners alike consider e-learning software systems to be a valuable platform for knowledge sharing and transfer tool in the educational world. Garrison (2011) pointed out that apart from reasons of knowledge transfer and education, academic institutions pursue the deployment of e-learning systems as a means to boost their revenues and retain market share of students in addition to improve national recognition or prestige.

Regardless all of the benefits discussed for e-learning as flexibility, convenience and the ability to remotely access and participate virtually in classrooms from the student's own comfort, the students may experience the feeling of isolation (Garrison, 2011). This is because the e-learning process is a solo act during most of the time which sets the learner to have the sense that they are acting completely alone. Although, a number of studies argued that the use of social computing technology can greatly overcome such setbacks and enhance the learners' satisfaction via growing stronger peer connections inside a virtual learning community to reduce the feelings of isolation (Johnson, Hornik, & Salas, 2008). Another concerning factor for the deployment of e-learning is the medical aspect as e-learning requires the use of computers and tablets. Consequently, bad posture, eyestrain and other physical issues may badly affect the learner's well-being. In the study by (Welsh et al., 2003), the authors listed further potential drawbacks for e-learning including higher up-front cost, lack of trainee interaction. The research study argued though that the drawbacks of e-learning systems can be compensated by the integration of blended learning as a hybrid form of traditional teaching with online learning. The Department of Education for the United States of America has further echoed concerns about distance education courses and programs that can lead academic institutions in directions that are not congruent and compliant with its mission of inculcating the learners with the rightful skills and knowledge.

History of E-Learning

Distance education has been around for more than a century whilst e-learning has started to evolve during the last two decades having a prominent impact on the educational and training paradigm for academic institutions, corporations and public administrations. For the origin of the term "e-learning", there is no reliable source documenting the birth of the word whilst there are some suggestions that the term is most likely originated during the 1980's (Moore et al., 2011). Other terms such as online learning

and virtual learning began to spring up during the same time in search for a better definition of exactly what was e-learning. The history of distance education dates back to the work of Sir Isaac Pitman for using courses delivered by the postal system in 1840's. Pitman decided to start a distance course via sending assignments to his students by post which they need to complete and send it back to him by post. It is claimed to be pioneering work for distance learning whilst the concept remained the same throughout the evolution of distance education for the exception of the delivery medium as the technology advanced enormously (Horton, 2011). Other studies trace back the idea of online learning to 1926 when the educationalist J. C. Stobart wrote a memo suggesting the creation of a "wireless university". In 1969, the establishment of the British Open University marked a turning point for the development of distance learning (Bates, 2005). It is no wonder that e-learning has its roots from mail-learning via correspondence courses. Educational content delivery format for distance learning have taken various forms including postal delivered instructions, materials in print format, classes over electronic medium, via smart devices and now, virtual classrooms.

The notion of a testing machine emerged initially in 1920's by Sidney Pressey who was an educational psychology professor at Ohio State University. Pressey invented a machine to provide drill and practice for students during his introductory courses. Pressey (1926) stated that: "the procedure in mastery of drill and informational material were in many instances simple and definite enough to permit handling of much routine teaching by mechanical means." In 1954, B. F. Skinner from the University of Harvard introduced a series of studies designed to improve teaching methods for spelling, mathematics, and other subjects by inventing a mechanical machine that would surpass the traditional teaching experience. Skinner believed that classrooms suffer from the drawbacks of learning rate for different learners being variable and reinforcement procedure is delayed because of the lack of individual attention to every student. Skinner was motivated by the fact that it is impossible to have a personal tutorial for every student all the times. He developed a theory of programmed learning which was to be implemented by teaching machines. The teaching machine consists mainly of a system program which contains teaching materials and test items that the student is gradually taken through them. The teaching machine is composed by fill-in-the-blank exercises where if answered correctly, the student gets a reinforcement and taken to the next questions. If otherwise, the learner is presented with the correct answer to increase later the chance of getting reinforced. The first computer-based training system was introduced in 1960 with the invention of the PLATO (Programmed Logic for Automatic Teaching Operation) program (Bitzer, Braunfeld, & Lichtenberger, 1961). It was originally designed for students attending the University of Illinois. The system has the basic layout which is used in modern e-learning applications consisting of graphic elements, textual information along with forums and chat rooms. With the rapid evolution of the internet and world wide web, e-learning began to take a new trend with the introduction of the first online web-based learning management system (LMS) in 1996 named as Cecil (Sheridan, White, & Gardner, 2002). Many new concepts and topics have floated up and flourished recently within the area of e-learning including the three major trends discussed next:

- **M-Learning:** The development of the mobile technology gave birth to a new era known as m-learning. Mobile learning can be defined as the portable and lightweight platform where the learner can engage in learning or training activities without having any geographical constraint via the use of mobile phones, smartphones, handheld computers, tablets, notebooks and media players. The mobility of the learner and portability of the hardware form the basis for the m-learning technology.

- **Micro-Learning:** Theo Hug was one of the earlier scholars to discuss the concept micro-learning which is a new form of learning in the field of adult learning and training (Hug, Lindner, & Bruck, 2005). It is regarded as a practical mode to achieve informal learning in a new uncluttered environment. Micro-learning is based on the design of micro or lighter activities through micro-steps in digital environments. These learning activities are made part of the learner's daily routines. Micro-learning is an important paradigm shift that avoids the need to have separate learning sessions since the learning process is embedded in the daily routine of the end-user. Unlike common e-learning approaches, micro-learning tends towards the use of push technology which reduces the cognitive load on the learners. The choice of micro-learning objects, timing and progression pace of micro-learning activities are of importance for didactical designs to keep the learners engaged with better efficiency.
- **Gamification:** Is defined as the use of game thinking, aesthetics and game mechanics in a non-game context to engage and motivate the learners and solve problems for an educational context. Basically it's the use of gaming technology to solve problems outside of the games sector. The word was first coined in 2002 by Nick Pelling, a British IT professional, but it was not widely used until 2010. Based on various research studies conducted by numerous educational scholars, what makes games effective and attractive for learning is the students' level of motivation, activity, interactivity, competition and engagement. A study performed by Traci Sitzmann from the University of Colorado, reported that staff trained on video games are willing to learn and acquire more factual information and attain a higher skill level with a high retention rate of knowledge longer than employees who are trained in less interactive environments (Sitzmann, Kraiger, Stewart, & Wisher, 2006). Sitzmann argued that regardless the fact that learners can be overwhelmed with high level of instructions within the game, the interactivity and the game elements make the game engaging leading to the conclusion that the engagement of the student in the game leads to efficient and satisfying learning experience. In (Connolly, Boyle, MacArthur, Hainey, & Boyle, 2012), the authors presented a literature review on gamification for e-learning focusing on positive outcomes. The study stresses on the necessity of more rigorous evidence on the effectiveness and real impact of gamification.

E-LEARNING PLATFORMS

The basic components of an e-learning process can be identified as: technological infrastructure, e-learning software platform, e-learning content and participants. The technological infrastructure refers to the communication medium and hardware platform hosting the e-learning operations. Educational materials are mostly transmitted via the internet although in the past, courses were delivered using a blend of traditional computer-based media such as CD-ROM. Technological tools for supporting the e-learning process involve the use of some or all of the following devices: desktop and laptop computers, interactive whiteboards, video cameras, mobile and wireless tools, including mobile phones. The most vital component for the e-learning process is the e-learning software platform which is usually named as the Learning Management System (LMS). The LMS is a software system developed for the purpose of managing online courses including the administration, documentation, reporting and delivery of educational and training programs. The e-learning software allows the instructor or institution administrator to manage every aspect of courses from the enrollment of students, delivering educational materials

in addition to the assessments part via digital delivery of assignments and exam preparations. Further, the LMS provides a platform for interaction between students and lecturers via the use of chat rooms or discussion boards or video conferencing. Most learning management systems are developed as web applications using various platforms including PHP, .NET and Java integrated with a classical relational database engine for storing data such as PostgreSQL, SQL server and MySQL. There are a number of features and functionalities that a learning management system should minimally offer for the achieving the ideal e-learning experience. Most systems are like to include most of the following features: Course Content Delivery, Student Registration and Administration, Event Scheduling, Tracking, Curriculum and Certification Management, Assignment and Assessment, Reporting and Courseware Authoring. There is a plethora of different e-learning systems in the market either coming as freely available as open source or commercial products. We review in this section the most popular learning management system having the dominant market share for the e-learning sector.

Moodle

Moodle is a free, online Learning Management system enabling lecturers and instructors to create their own private website filled with dynamic courses that extend learning anytime and anywhere. Developed on pedagogical principles, Moodle is used for blended learning, distance education, flipped classroom and other e-learning projects in schools, universities, workplaces and other sectors. The recent version of Moodle supports responsive design giving the users the ability to create mobile-friendly online courses and integrate third party add-ons. Moodle is an acronym for Modular Object-Oriented Dynamic Learning Environment developed by Martin Dougiamas in 2002 using the PHP programming language. In terms of usage, Moodle is the second largest provider with 23% market share, following Blackboard (41%) whilst having the most number of users estimated to be over 70 million registered students. Although, the software enjoys richer functionalities and robustness, the main drawback for using Moodle is the perceived complexity for new users (Harrati et al., 2016).

Blackboard Learn

Blackboard Learn which is commonly known as Blackboard, is a web-based content management system created in 1997 by faculty members at Cornell University as a course management system for education. Blackboard helps creating a virtual place or classroom where the interaction between students and their instructors is achieved through the use of discussion forums, email, chat rooms and other functionalities. The LMS can be extended and customized according to various needs of the institutions. It is one of the most popular and successful commercial e-learning systems.

Claroline

Claroline is a collaborative online learning and working open source platform released under the GPL open source license. It offers the possibility for many institutions to create and administrate collaborative online learning spaces. Claroline is available in more than 100 countries and is translated to 35 languages. The use of claroline is intuitive and easy and does not require particular skills. Claroline is compatible with GNU/Linux, Mac OS and Microsoft Windows. It is based on PHP and MySQL as the widely used relational database management system.

EdX

EdX is an open-source and free learning management system offered by edX.org. It is the same framework that universities such as MIT and Harvard utilize to offer online education to over 100,000 students. It was released as open source in March 2013, and the goal was to act as the WordPress for Massive Open Online Course (MOOC) platforms, allowing developers and users to integrate plug-ins to expand the core functionality of the system. edX has a fast, modern feel, with the ability to accommodate large enrollments. Although it is an open source, investment will need to be made in both installation and maintenance of the system.

Sakai

Sakai is a service-oriented Java-based open source learning management system founded in 2004 by the universities of Michigan, Indiana, Stanford and the Massachusetts Institute of Technology with the purpose to develop a new LMS as scalable, reliable, interoperable and extensible. The project was funded by a grant from the Mellon Foundation. Sakai is deployed at over 300 academic institutions for offering online education.

ASSESSMENT AND EVALUATION

The terms assessment and evaluation have been often used synonymously in the education area but they have different semantics when it comes to the area of e-learning. Assessment is used usually to refer to the role in formal education of judging the students' attainment of educational objectives for a specific course (Garrison, 2011). Student assessment is by nature multifaceted that includes exploring different aspects as the acquisition of skills, competencies, capacity to apply critical and creative solutions to challenging problems within different contexts. Generally, the assessment process occurs throughout the course in order to provide formative and continuous feedback for the learners whilst offering summative assessment information on learning accomplishments to both student and instructor at the completion of the course. Assessment of student learning is a key component of the evaluation of the e-learning paradigm and it is among other factors with which educators involved in e-learning are concerned. Black and Wiliam (1998) argued that feedback can have a remarkable effect on self-esteem and motivation, which in turn can influence directly how and what the student can learn. Assessment via the use of technological systems which sometimes called e-assessment, can allow students to engage more with certain level of confidence to their own learning as opposed to norm-referenced comparisons to their fellow students. The ability to easily review and revisit records and feedback of their own learning activities and its outcomes is considered to be an important aspect for the assessment process (Pachler & Daly, 2011). This is referred as the self-regulation for e-learning which is defined as the control by students for aspects of their own learning.

On the other hand, evaluation is used to refer to the process of comparing or measuring a unit, course, program or other elements of e-learning against some set of performance or outcome criteria. Comprehensive evaluation spans to measures of satisfaction, perception of learning, costing and cost benefits, and other criteria for assessing the success as defined by the relevant stakeholders and participants. Effective evaluation of e-learning process requires a close examination of the instructional design incorporated

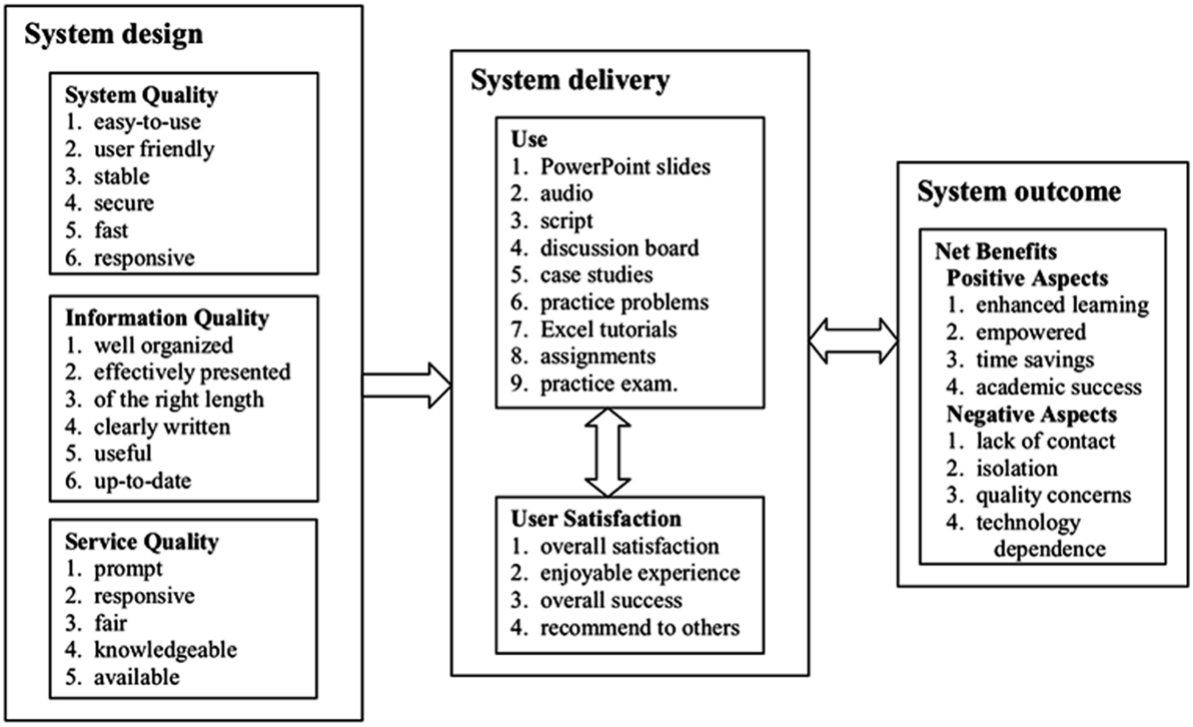
during the course. Garrison et al. (2011) listed different types of proactive evaluation starting with determination of the strategic intent of the e-learning program. Being able to clearly determine the reasons why the particular pedagogical program has been developed for online learning is critical to assessing its effectiveness. The second form of proactive evaluation is to look closely at the content of the courses and examine the cohesion and consistency aspect in addition to the ease of access of modification. The third element of evaluation focuses on an examination of the interface design for the learning management system. An effective graphical interface is mastered by users with ease and gives the possibility to present the educational content in a variety of formats including graphics, video, and other advanced interactive and dynamic formats. The design of the interface should be based on a familiar metaphor that will help the users navigate among the different components of the course. The graphical interface should be customizable by both the students and the educators to increase their comfort and the readability of the educational content. The fourth form of evaluation is about to assess the amount of interactivity supported by the course and the learning management system. Garrison (2011) concluded that the final evaluation process revolves around the quality, quantity and thoroughness of the assessment of student learning and engagement for using the e-learning system.

In spite of the widespread use of e-learning systems and the substantial investments in purchasing, developing and maintaining learning management systems, there is no consensus yet on devising a standard framework or taxonomy for evaluating the quality and effectiveness of e-learning systems. The dearth of conventional e-learning system quality models is in stark contrast compared to the considerable body of work on software quality assurance. Chua et al. (Chua & Dyson, 2004) proposed the ISO 9126 Quality Model as a useful framework specifically for evaluating learning management systems with particular emphasis for teachers and educational administrators as the primary stakeholders. The ISO 9126 evaluation model was adopted by the International Organization for Standardization (ISO) and is considered as one of a large group of internationally recognized standards. Although, the authors have stressed on the potency of the model as a useful evaluation tool that can crystalize better insights relevant to the educators, the ISO 9126 model has not been used extensively within the e-learning environment. Holsapple et al. (Holsapple & Lee-Post, 2006) introduced the E-Learning Success Model which is adapted from DeLone and McLean's Information Systems success model which, in turn, is an extension of their original model. The e-learning success model depends on the attainment of success at each of the three stages of the e-learning process including: system design, system delivery, and system outcome. Figure (1) shows the e-learning success model with the different sub-components for each of the three stages.

USABILITY EVALUATION

As more and more universities worldwide have opted to use online technology for their course delivery, research in e-learning systems have attracted considerable interest in order to apprehend how effective and usable e-learning systems in terms of principles related to human computer interaction (Bringula, 2013; Escobar-Rodriguez & Monge-Lozano, 2012; Navimipour & Zareie, 2015). Positive user experience emerges as an important pillar for the adoption of educational learning systems. This is mainly because the availability of technological infrastructures and systems is not adequate to enforce the uptake of new educational approaches from both sides of the teachers or the learners (Laurillard, Oliver, Wasson, & Hoppe, 2009; Persico, Manca, & Pozzi, 2014; Phillips, McNaught, & Kennedy, 2012). Usability nature of e-learning software products is a key characteristic to achieve the acceptance and satisfaction for both

Figure 1. E-Learning Success Model (Holsapple & Lee-Post, 2006)



players regardless of their background, experience or orientation. The satisfaction part is related to how the users believe or feel positively that the system meets their requirements (Capece & Campisi, 2013; Islam, 2014; Lee, Kim, & Lee, 1995; Yeh & Lin, 2015). Meanwhile, other researchers have defined satisfaction as the gap between the expected gain and the actual gain when using the system (Tsai, Yen, Huang, & Huang, 2007). Positive user experience is of prime importance for online systems playing vital role for technology acceptance as well as the continuous commercial success of software companies. Considerable research within the human-computer interaction literature concerns the analytical quantification of the various factors that determine and shape software usability (Albert & Tullis, 2013; Hornb\aek, 2006). Most examined covariate factors are related to the user such as age, academic level, social status, gender or specific impairments (Mentes & Turan, 2012; Pariente-Martinez, Gonzalez-Rodriguez, Fernandez-Lanvin, & De Andres-Suarez, 2014). In spite of the fact that there are numerous research studies on child-computer interaction, performance rates of older people and accessibility for users with special needs, most web applications are designed and developed for younger people whilst ignoring other groups of users with specific requirements. Without doubt, studying these factors along with the involved constraints of these groups is crucial in order enhance the system usability and adapt the user interface to different user requirements.

Usability is defined as the extent to which a product can be easily used by specified users to achieve certain goals with effectiveness, efficiency and satisfaction (Mayhew, 1999). In practice, the usability aspect of software products is marginalized during the classical stages of software development life-cycles pushing more efforts and resources into the software back-end to address the functional requirements (Burton-Jones & Grange, 2012). In fact, regardless of how software are neatly coded or sophisticated,

recent studies of software sales reports that software failures are due to usability reasons where simply the user does not know how to use the purchased product (Cassino, Tucci, Vitiello, & Francese, 2015). Software systems are valued on the basis of its graphical interface and the related power of communication and expression for the implemented functionalities (Cassino et al., 2015). It is no doubt that usability is now recognized as an important software quality attribute, earning its place among more traditional attributes such as performance, robustness, content and security (Henriksson, Yi, Frost, & Middleton, 2007; Ismailova, 2015). Moreover, research focus has shifted recently from the study of "use" to exploring ways of effective and ease of use for information systems (Burton-Jones & Grange, 2012).

Usability Evaluation Methods

The process of usability evaluation consists of methodologies for measuring the ease-of-use aspects of the user interface for a given software system and identifying specific problems. In fact, Usability evaluation plays a vital role within the overall user interface design process which undergoes continuous and iterative cycles of design, prototyping and testing. Evaluating the usability of interactive systems is itself a process involving various activities depending on the method utilized (Ivory & Hearst, 2001).

Empirical Methods

Empirical-based usability methods require the participation of end users who are instructed to interact with the software system. Meanwhile, their behavior and interaction with the system are recorded and observed by an expert. Results are obtained from the users through interviews and questionnaires where they are asked for their opinions and concerns in addition to possible suggestions of how to improve better the interface design and its usability. Interestingly, there is a recent trend of using medical equipment for assessing the user satisfaction level for using information systems. Dimoka et al. (2012) pointed out to the potentials of employing brain imaging and psychophysiological tools such as skin conductance response, eye tracking and facial Electromyography (Eckhardt, Maier, & Buettner). Liapis (Liapis, Katsanos, Sotiropoulos, Xenos, & Karousos, 2015) conducted research experiments to recognize stress through analysing skin conductance signals. This was carried out as part of an evaluation of user emotional experience in order to identify stressful tasks in human-computer interaction. In fact, one of the challenges in software development is to involve end users in the design and development stages so as to observe and analyze their behavior to collect feedback in effective and efficient manner.

There is number of methods and theories in the literature for understanding, predicting, and assessing the interaction process with its involved parts including personal factors, behavior, and the environment. In order to assess the user acceptance of technological products, one of the most well established models is the Technology Acceptance Model (TAM), which was proposed by Davis (Davis, Bagozzi, & Warshaw, 1989). The TAM is tailored to include questions to explore two aspects of the user satisfaction which are: perceived ease-of-use and perceived usefulness. The ease of use refers to how users believe that adopting a particular technological product would require no effort and hassle to use it (Davis et al., 1989). The perceived usefulness concerns the degree to which a user believes that using a particular software system would improve their job performance. The Technology Acceptance Model has been used in various studies to assess the factors affecting individual's to the use of technology (Venkatesh & Davis, 2000). There are other related models and theories such as the System Usability Scale (SUS) which was proposed mainly for the evaluation of web application for two aspects; the learnability and

Table 1. System Usability Scale for Usability Evaluation (Brooke, 1996)

	Strongly disagree			**Strongly Agree**	
	1	**2**	**3**	**4**	**5**
1. I think that I would like to use this system frequently.					
2. I found the system unnecessarily complex.					
3. I thought the system was easy to use.					
4. I think that I would need the support of a technical person to be able to use this system.					
5. I found the various functions in this system were well integrated.					
6. I thought there was too much inconsistency in this system.					
7. I would imagine that most people would learn to use this system very quickly.					
8. I found the system very cumbersome to use.					
9. I felt very confident using the system.					
10. I needed to learn a lot of things before I could get going with this system.					

usability. The SUS is a well-researched and widely used questionnaire for assessing the usability of mostly web applications. The System Usability Scale (SUS) (Brooke, 1996) is one of the most popular methods in the literature which is devised mainly to evaluate the usability for web applications. Its popularity is gained among the HCI community mainly due to its desirable psychometric metrics including high reliability and validity (Bangor, Kortum, & Miller, 2008; Brooke, 1996; Lewis & Sauro, 2009). The SUS questionnaire is composed of ten questions with a mix of positive and negative items. For each question, the respondent rates the magnitude of their agreement using a 5-point Likert scale with statements going from strongly disagree (1) to strongly agree (5). In order to compute the overall SUS score, the score contribution for each odd question which is positively worded, is estimated as the scale minus 1. For the even items, the score contribution is 5 minus the scale position. Therefore, each contribution ranges from 0 to 4. The SUS is the sum of all score contributions for the 10 items multiplied by 2.5 as shown in Equation (1) where U_i refers to the rating of the i^{th} item. The SUS scores ranges between 0 and 100 in 2.5-point increments where higher values reflect higher satisfaction from the user.

$$SUS = 2.5 \times \left[\sum_{n=1}^{5} \left(U_{2n-1} - 1 \right) + \left(5 - U_{2n} \right) \right] \tag{1}$$

Inspection-Based Methods

Alternatively, usability evaluation can be carried out through inspection methods which aim to identifying interaction problems within the interface without the involvement of end users. The interface is assessed manually by an expert or usability consultant for compliance to a set of predefined usability guidelines or conventional set of heuristics to detect usability deficiencies (Fernandez, Abrahão, & Insfran, 2013; Fernandez, Insfran, & Abrahão, 2011). The most-used usability heuristics for user interface design are those developed by Jackob Nielsen and Rolf Molich in 1990. Jakob Nielsen (1994) summarized ten heuristics for user interface design. A description to these heuristics is outlined briefly in Table 2.

Table 2. Nielsen's 10 heuristics for user interface design

Heuristic	Description
Visibility of system status	The system should provide users with the status and progression of the tasks they are doing.
Match between system and the real world	The system's language and logical appearance of information should be homogenous and compatible with users
User control and freedom	The user should be giving the option of canceling, undoing or redoing a task
Consistency and standards	The design should conform to interface standards so that users are not confused with names and situations of words, commands and actions
Error prevention	Systems should eliminate or prevent the occurrence of errors by error checking mechanisms for example confirmation options
Recognition rather than recall	System objects should be clearly visible to minimize the memory load.
Flexibility and efficiency of use	Using accelerators like shortcuts is desirable to expert users to speed up the interactions with the system.
Aesthetic and minimalist design	Dialogs should be as simple and relevant as possible.
Help users recognize, diagnose, and recover from errors	Error messages should be expressed in plain language (no codes), precisely indicate the problem, and constructively suggest a solution.
Help and documentation	It is better to give a rubric for help and documentation, help contents should be simple and brief and easy to search

Automated Usability Evaluation

Inspection or empirical approaches involve usability practitioners to manually examine a graphical user interface in order to detect usability deficiencies via inspecting usage test cases or analyzing the results of questionnaires. Although such methods are known to be laborious and very expensive, they often yield results that are biased by the acquisition environment or experts' subjectivity. Alternatively, several automated evaluation methods are conceived for auto discovery of usability faults at the same time avoiding the drawbacks in terms of reducing costs and time through liberating usability experts from conducting repetitive tasks manually in addition to increase the coverage of tested features (Quade, Lehmann, Engelbrecht, Roscher, & Albayrak, 2013). Furthermore, because of the immense volume of data acquired from usability evaluation, the total or partial use of automated methods can be very beneficial during the development of web applications (Cassino et al., 2015; de Santana & Baranauskas, 2015). However, the majority of the surveyed research studies are purely based on manual or statistical analysis of recorded activity data for the participants.

Usability evaluation can be conducted by users either remotely or locally. Tullis et al. (Tullis, Fleischman, McNulty, Cianchette, & Bergel, 2002) conducted a comparative experiment between remote and laboratory-based testing where they emphasized the advantages of remote evaluation in terms of costs and effectiveness. Methods for usability evaluation are conventionally grouped into two main categories by the HCI community; the first class is based on analyzing the graphical interface through reading the source code of the website to examine the content and structure of the application. Cassino et al. (2011) assessed the source code to infer the design model of the interface and the interaction styles implemented on every page of the website to generate a quantitative report of the evaluation based on heuristic factors. Meanwhile, other methods rely on examining the usage data i.e. logs. The user logs used for usability evaluation are captured at either the server-side or the client-side. Many studies advocate that logging

techniques are proven to be more reliable and efficient in terms of providing useful usability insights for the evaluators (de Santana & Baranauskas, 2015).

Server-side logs are automatically generated by the web server where each line in the log file corresponds to a request made by a user to access a given resource on the server such as an html page or image. Server logs can be analyzed to produce usability insight from many real users performing particular tasks over a long period of time in natural working conditions as opposed to simulated or artificial settings within a laboratory having a limited sample of users (Geng & Tian, 2015). Data preparation and mining methods are used to process the raw web server logs to derive the users visiting patterns and other metrics for usability analysis. The process of data preparation from log files consists of data cleaning, user sessions re-identification across different requests and navigation path completion. However, Geng (Geng & Tian, 2015) pointed out that the task for log processing is time consuming and computationally intensive. On the other hand, many critics argued that recorded server logs contain bare information about the users' goals and lacking essential data about the in-page interactivity and events.

For the client-side logs, user usage data is acquired through either data loggers integrated into the web application or via the use of custom browser plugins or 3rd party software to enable the tracking of user activities. Client-side logs can acquire accurate and detailed comprehensive user traces for usability evaluation as the logger is usually implemented via custom event listeners to record low-level user interaction events such as keystrokes and mouse clicks. Hence, the recorded data contains elaborate details about the user interaction with the interface via a particular input device. Events are triggered from actions that are generated either by the user or the system. The main setback of using client-side loggers is the privacy concerns as users need to legally grant their permission in order to record their activity traces on a given website. Further, users generally are not willing to have additional software installed on their computers to record their activities online (Geng & Tian, 2015). Therefore, capturing client-side data can best be achieved in laboratory settings where explicit consent of the users can be provided.

Website Evaluation Tools

Paganelli (2002) worked on developing a desktop-based application for recording and analysing interaction logs for website systems based on a predefined task model. The activities to be performed on a website is specified using the notations for the ConcurTaskTrees environment (Paternò, Santoro, & Spano, 2012) which provides a graphical representation for the hierarchical logical structure of the task model. Tiedtke (Tiedtke, Märtin, & Gerth, 2002) described a framework implemented in Java and XML for automated usability evaluation of interactive websites combining different techniques for data-gathering and analysis. Their system uses a task-based approach and incorporates usability issues. Atterer and Schmidt (2007) presented an implementation of UsaProxy which is an application that provides website usage tracking functionality using an HTTP proxy approach. Recently Vasconceols (de Vasconcelos & Baldochi Jr, 2012) implemented an automated system called USABILICS for remote evaluation based on interface model. Tasks to be performed by a user are predefined using an intuitive approach that can be applied for larger web systems. The evaluation is based on matching a usage pattern performed by the user against the one conducted by an expert of the system providing a usability index for the probed application. Muhi (Muhi, Sz\Hoke, Fülöp, Ferenc, & Berger, 2013) proposed a general framework for usability evaluation that can be tested in production systems. The framework takes as input an XML configuration file describing the positioning of the different interface elements of an application whilst user activities are logged into a separate XML file. A validator module is deployed to check the log-files

according to semantic rules that are defined within the usability data model. Andrica and Candea (2011) presented the WaRR which is an automated tool that records and replays with high fidelity the interaction between users and modern web applications in this tool the recording functionality is embedded in the web browser, it has direct access to user keystrokes and clicks.

There are a number of commercially available tools that are used for recording user traces for usability purposes. CrazyEgg logs mouse events with the ability to visualize activity maps of the more popular locations of clicks on a page. Web Criteria Site Profile is another tool used mainly to assess simple attributes of usability including page loading time and ease of finding content on a website. This is based on automated agents browsing the website to retrieve data making use of the GOM model. Web TANGO is a software that employs the Monte Carlo simulation and information retrieval methods to predict the user's behavior and navigation paths. This is based on data acquired from extensive experiments conducted against websites nominated as successful having received higher user ratings.

Usability For E-Leaning Systems

For research studies related to assess the usability aspect of the learning management systems, Persico (Persico et al., 2014) employed the Technology Acceptance Model to investigate the willingness of university users for the adoption of e-learning systems. Evaluation is based on three dimensions including usefulness, ease of use and effectiveness. Escobar-Rodriguez (Escobar-Rodriguez & Monge-Lozano, 2012) analyzed how university students use the Moodle platform in order to determine and understand the factors which might influence their intention to use the platform. The Technology Acceptance Model is used to assess the usability of the system in terms of perceived usefulness and ease of use against actual usage behavior. Surprisingly, only a few studies in the literature have used SUS to evaluate the perceived usability of e-learning management systems (Orfanou, Tselios, & Katsanos, 2015). The first study of using the SUS for e-learning system was conducted by (Renaut, Batier, Flory, & Heyde, 2006) to inspect usability problems for the SPIRAL platform. The researchers employed the SUS scale as a post-assessment of the usability reporting a score of 72% of the participating university lecturers who described the platform as positively easy to use. In (Simões & de Moraes, 2012), the authors examined the usability of the Moodle e-learning platform using three different evaluation methods including the SUS questionnaire to assess user's satisfaction for a sample size of 59 students. The authors concluded that the SUS is an effective tool for exploring the usability aspect without reporting the obtained SUS score. Marco et al. (2013) proposed a way of remote collaboration in real time within the platform Moodle through the use of Drag & Share. The collaborative tool enables sharing and synchronization of files. The efficiency of users was quantified using the time taken for task completion meanwhile user satisfaction was assessed using the SUS questionnaire with a reported score of 89.5%.

Because of the dearth of studies and approaches devoted for the exploratory evaluation of the acceptance and usability aspect by university lecturers for using e-learning applications. Motivated by the fact that the process for introducing e-learning systems is bound to have a slow and complex trend () which needs to be understood and evaluated beyond the use of just summative ways, Harrati et al. () explored an empirical-based study to assess the satisfaction level of how lecturers interact with an e-learning environment system based on a predefined task model describing low-level interactivity details. The main thrust of this research is to evaluate the usability of the e-learning platform as usability is considered a vital attribute for the adoption of educational systems by lecturers. An online automated system for formalizing user interaction with a given system guided through a set of rules describing certain goals

to be achieved by the end user is setup for usability practitioners. The task model is mainly utilized to capture all the interactions and navigation path to be carried out by the university staff. Empirical client-side log data is collected from university lecturers from the Electrical and Computer Science departments participating within the usability evaluation of the e-learning system in a non-intrusive fashion without the need to install additional tools. The Moodle e-learning platform is used as the case study for this research. Subsequently, data analysis is conducted to infer the usability level. This is carried out in compliance with the defined task model and usability metrics describing efficiency of use. Regardless of the fact that users have expressed higher satisfaction scores through the System Usability Scale (SUS) (), empirical results performed to inspect the usability of the e-learning platform have revealed that potential reasons to impede the adoption of new technologies within the teaching process is primarily related to the complex nature of the software interface where the majority of lecturers failed to complete simple tasks.

CONCLUSION

Because of the vital importance for the use of online technology as a medium for distance or virtual education, corporations and schools are investing substantially large amounts of money, time and resources in developing alternatives to traditional methods of education and training. In fact, several scholars described the growth rate of e-learning as unprecedented and explosive as the adoption of e-learning went beyond academic institutions to be considered seriously in corporate companies and public administrations as part of their employee training programs. Because of the ubiquity of e-learning and vital influence for engineering the educational process, it is no surprise that many research studies are conducted to explore different aspects covering the use of e-learning in higher education. The assessment and evaluation aspects are considered arguably the most influential part for measuring the success and effectiveness of e-learning experience. As more and more universities worldwide has opted to use online technology for their course delivery, research in e-learning systems have attracted considerable interest in order to apprehend how effective and usable e-learning systems in terms of principles related to human computer interaction. Usability evaluation consists of methodologies for measuring the ease-of-use aspects of the user interface for a given software system and identifying specific problems. In fact, Usability evaluation plays a vital role within the overall user interface design process which undergoes continuous and iterative cycles of design, prototyping and testing.

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KEY TERMS AND DEFINITIONS

Assessment: Is used usually to refer to the role in formal education of judging the students' attainment of educational objectives for a specific course.

Blended Learning: Refers to the teaching process where computer-based learning are integrated in tandem with face-to-face classical teaching activities.

E-Learning: Is the learning process facilitated and supported through the use of information and communications technology.

Evaluation: Refers to the process of comparing or measuring a unit, course, program or other elements of e-learning against some set of performance or outcome criteria.

Learning Management System: Is a software system developed for the purpose of managing online courses including the administration, documentation, reporting and delivery of educational content.

Micro-Learning: Is a new form of learning based on the design of micro or lighter activities through micro-steps in digital environments. These learning activities are made part of the learner's daily routines.

M-Learning: Is defined as the portable and lightweight learning process where the learner can engage in learning or training activity without having any geographical constraint via the use of their mobile machine in a portable and mobile fashion.

Usability: Is the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use.