Evaluating the Acceptance of e-Learning Systems via Subjective and Objective Data Analysis

Imed Bouchrika, Nouzha Harrati, Zohra Mahfouf and Noureddine Gasmallah

Abstract The adoption of e-learning technology by the academic community, has been a long source of research from multiple disciplines including education, psychology and computer science. As more and more academic institutions have opted to use online technology for their course delivery and pedagogical activities, there has been a surge of interest in evaluating the acceptance of the academic community to adopt and accept the use of e-learning management systems. This is due to the increasing concerns that despite the wide use and deployment of e-learning technologies, the intended impact on education is not achieved. We review the conducted studies on the use of objective procedures for evaluating e-learning systems in tandem with subjective data analysis. The evaluation process consists of understanding further the factors related to the acceptance and adoption of online educational systems by instructors and students in order to devise strategies for improving the teaching and research quality.

Keywords e-learning · Usability evaluation · Learning management system Subjective evaluation · Objective evaluation · e-learning adoption

1 Introduction

Because of the ubiquitous use of computers and smart devices combined with the availability and affordability of internet connectivity in most places, information sys-

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tems have become an integral part of our daily life in such a modern society. The uptake of online technology within the academic arena has greatly reshaped and transformed the way we teach, work and conduct research. Considerable amounts of funding and efforts are being devoted to deploy and modernize information systems in order to improve individual and institutional performance for course delivery. This is eased with the birth of a new generation of undergraduate students being considered as the digital natives who have grown up for their whole lives surrounded by the use of computers and online technologies (Joo and Choi 2015). Although, there are advocates within the university community who still prefer traditional teaching methods which include face-to-face communication, unprecedented efforts are set to promote and embrace the use of new technology and e-learning for teaching, communication and research. Numerous recent studies (McGill et al. 2014) have stressed that educational innovations can wither and be subverted if technological initiatives are not maintained and adopted by the educational community. In fact, academics play a pivotal role for the successful uptake and acceptance of digital infrastructure via enriching the e-learning platforms with pedagogical materials to supplement their teaching activities in addition to publishing their e-textbooks and research contributions within the academic online portals.

The use of e-learning in academic and corporate institutions has gained popularity mainly due to the perceived advantages of flexibility around fitting the learner's time requirements and overcoming the issue around the geographical restrictions. In fact, the 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 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, traveling 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 et al. (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) suggested 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 et al. (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.

As more and more academic institutions have opted to use online technology for their course delivery and pedagogical activities, there has been an increasing interest in evaluating the acceptance of the academic community to adopt learning management systems. In this book chapter, we review the conducted studies on the use of objective procedures for evaluating e-learning systems in tandem with subjective data analysis. Regardless 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 evaluation consists of understanding further the factors related to the acceptance and adoption of online information systems by higher education staff in order to devise strategies and to enhance and improve the teaching and research quality. Further, research on e-learning systems in addition to the linkage between information systems and staff performance have attracted unprecedented interest in order to better apprehend how effective and usable e-learning systems in terms of principles related to human computer interaction (Navimipour and Zareie 2015; Bringula 2013; Escobar-Rodriguez and Monge-Lozano 2012) and human behavior (Roca and Gagné 2008; Liaw et al. 2007). Numerous research studies concern the analytical quantification of the various factors that determine and shape the acceptance of academic online systems (Albert and Tullis 2013; Hornbæk 2006) in addition to assessing the behavioral aspect of users including students and academic staff.

2 e-Learning Management Systems

The main components which contribute to the functioning of an e-learning process can be identified as: technological infrastructure, educational content, participants and e-learning management system. The technological infrastructure refers to the communication medium and hardware platform hosting the e-learning operations. Educational content used to be delivered via the postal services using a blend of traditional computer-based media such as CD-ROM where users can learn remotely in total asynchronous mode. Nowadays, transmission of teaching materials is done via the internet where the learners can get fresh content with instant feedback and can even collaborate and communicate with other peers or instructors. 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) or also known as Virtual Learning Environment (VLE). In fact, there is no consensus on the precise definition of an LMS as e-learning systems are continuously evolving to accommodate new features and adopt emerging concepts. The LMS is a software system developed for the purpose of managing online courses including 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. A learning management system can assist academic or corporate institutions to protect and safeguard their teaching and training materials as they have invested substantially to create them as they cannot risk lost revenues when making such valuable resources publicly available. Further, one of the merit of deploying learning management software is to provide a "*walled garden*" where learners can develop a sense of community away from abusive and disruptive internet users under the guidance of their instructors (Mott 2010).

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 achieving the ideal e-learning experience. Most systems are likely 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. Further, the LMS provides a platform for interaction between students and lecturers via the use of chat rooms or discussion boards or video conferencing. There is a plethora of different e-learning systems in the market either coming as freely available as open source or commercial products. We have classified learning management systems into two main categories namely: (i) *On-premise* and (ii) *Cloud-Based SaaS*. The classification is based on the installation paradigm as explained in this section. Further, we review some of the popular learning management systems having the dominant market share within the e-learning sector. The list of the reviewed software systems are summarized in Table 1.

2.1 On-premise Software

Learning management systems which run on-premise are usually installed and self-managed either locally or even installed remotely on a traditional rented dedicated hosting space. The main benefit of using on-premise software is to have complete control of ownership to the software license and ability to modify or upgrade the system. Further, the system can be customized or extended to suit the requirements that the institutions believe would be relevant to their teaching paradigm and curriculum. A prime reason for schools and universities to use in-house solutions is the privacy concern as academic institutions can be legally bound to keep their student data private and therefore in-house hosting for their learning management system is a solution to comply with legislative requirements. The main drawback of self-managed learning management system is the maintenance which involves upgrading the software and hardware infrastructure from time to time in addition to taking regular backups and conducting data recovery in case of a hardware failure. For the cost aspect, on-premise software can cost substantially more and requires dedicated and well-trained staff to maintain the platform.

Table 1 List of learning management systems

	On-premise LMS					Saas cloud-based LMS		
	Moodle	Caroline	Blackboard	Sakai	edX	Google C.	TalentLMS	DoceboLMS
Free	✓	✓		✓	✓	✓		
e-Assessment	✓	✓	✓	✓	✓	✓	✓	✓
Personalized Lear.			✓	✓			✓	✓
APIs	✓		✓		✓	✓	✓	✓
Gamification			✓				✓	✓
M-Learning	✓	✓	✓	✓	✓	✓	✓	✓
Forums	✓	✓	✓	✓	✓	✓	✓	✓
Cloud storage					✓	✓	✓	✓
Localization	✓	✓	✓	✓	✓	✓	✓	✓
Collaboration	✓	✓	✓	✓	✓	✓	✓	✓
SCORM/xAPI	✓		✓	✓			✓	✓
e-Commerce			✓				✓	✓

Moodle is an acronym for Modular Object-Oriented Dynamic Learning Environment developed by Martin Dougiamas in 2002 using the PHP programming language. The software is an online Learning Management system that can be downloaded by academic institutions for free to enable their lecturers and instructors to create webpages filled with dynamic courses that extend learning anytime and anywhere. Although Moodle provides an Application Programming Interface (API) access, installing and integrating the platform with existing infrastructures require high level of technical expertise. 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 (3.3.2) supports responsive design giving the users the ability to create mobile-friendly online courses and integrate third party add-ons. 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).

Claroline is a collaborative online learning management system which is provided to download and install as an open source platform released freely under the GPL open source license. 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. The software offers the possibility for many institutions to create and administrate collaborative online learning spaces featured with many tools including blogs, wikis and forums. Claroline is being deployed in more than 100 countries and translated to 35 languages. The use of Claroline is intuitive, easy and does not require particular skills. Although Caroline provides support for integration with existing infrastructure using LDAP, the platform does not have an API for flexible integration.

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. It is one of the most popular and successful commercial e-learning systems. 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. Blackboard Learn supports seamless integration with cloud-based providers for synchronizing and downloading files including Dropbox and OneDrive. Further, the platform provides personalized learning for students through the use of profiles. The LMS can be extended and customized according to various needs of the institutions. In the same way to Moodle, Blackboard created an API for the learning management system for the ease of integration with other software and database systems.

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 (MIT) with the purpose to develop a new learning management system 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. Although the

platform features a rich list of functionalities for collaboration, teaching and communication, Sakai does not provide an API for developers to integrate the platform with their existing systems.

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. An API is provided for institutions to easily integrate edX with their existing systems mainly to enroll and manage students. The platform is made responsive to improve the accessibility aspect for mobile platforms.

2.2 Cloud-Based SaaS

e-Learning systems can be deployed easily as *Software as a service (SaaS)*. Academic or corporate institutions can create a working e-learning management system for their students without the requirement to download or install any extra software. Usually, there are commercial providers who provide an online interface for customers to create and manage their learning management systems which can be created as in instance on a centralized hosting platform commonly known as a cloud-based platform. The *cloud* in computing is defined as "*a large pool of easily usable and accessible virtualized resources. These resources can be dynamically re-configured to adjust to a variable load, allowing also for an optimum resource utilization*" (Vaquero et al. 2008). The main reason for people to migrate towards using cloud-based solution is the scalability concern in order to account for the increasing numbers of users, teaching materials and computing resources. This is because cloud-based solutions can handle sudden and increase spikes of usage via load balancing or distribution of requests and data across multiple servers.

Outsourcing the software as a service within a cloud-based environment can cost less whilst the technical aspect is taken care of by the service provider including support and assistance. Barlow et al. (2007) reported that Arizona State University has made a saving of $450,000 per year when migrating to use cloud-based email services provided by Google. Although, there are risks and drawback to rely heavily on cloud-based solutions as there is no guarantee that the service provider will last in business forever in addition to future pricing plans, policy changes or software upgrades can impact severely academic institutions who have relinquished total control to the cloud provider for the data and the e-learning software. In fact, a small change to the interface of the learning management system could make all the documentation or instructional videos provided by the institutions totally obsolete and misleading. There are a number of learning management systems which are

developed purely for a cloud environment including the list reviewed in this section followingly. Interestingly, there are companies emerging recently to offer the installation of *on-premise* software within their cloud farm for a monthly cost.

Google Classroom is a learning management system developed by Google as part of the G Suite for Education in 2014. The platform is offered at no cost to academic institutions along with other cloud-based applications including word processor, email, calender and unlimited access to Google Drive storage services. Google Classroom aims to create a paperless learning experience where teachers can create online classes, set assignments and monitor their students. The platform has a mobile native applications for Android and iOS smartphones to support m-learning. For developers, Google released an API to interact programmatically with the cloud-based learning management system.

DoceboLMS is a fully featured cloud-based SaaS e-learning management system used mostly for companies and corporation to train their staff or sell courses online. The platform was initially developed as on-premise software and later was moved to operate as a cloud-hosted platform. DoceboLMS supports major features including e-assessment, wikis, localization, e-commerce and certification. Gamification is supported within DoceboLMS to help increase the users' engagements with the online system through the deployment of gaming mechanics in a non-gaming context. The platform is available for smart phones. For integration and enrollment of users, there are APIs available that can be invoked to interact with the cloud-based platform.

TalentLMS is Service as a Software e-Learning platform created with a number of functionalities including e-assessment, forums, certification, gamification and online authoring tools. Recently, The cloud LMS is reported to have a better usability rate of its user interface compared to other complex systems. There is the possibility for users to integrate other external cloud-based services such as Dropbox and Gmail. For mobile learning, there are native applications implemented for iOS and Android phones with the same features as the desktop online applications. For integration with existing infrastructures, TalentLMS provides extensive REST API functions to import and manage users as well as content and course creation.

3 Adoption of e-Learning Systems

The decision of whether a user will accept and adopt to use a specific innovation or technological product along with the time frame involved to decide to use, have attracted considerable research interest across multiple research communities to explore why there are people who choose to accept a technology whilst there are other individuals who resist (Straub 2009; Harrati et al. 2016). The adoption goes beyond the simple choice to accept an innovation to the extent where the new product is integrated and deployed into the appropriate context of use (Straub 2009). There

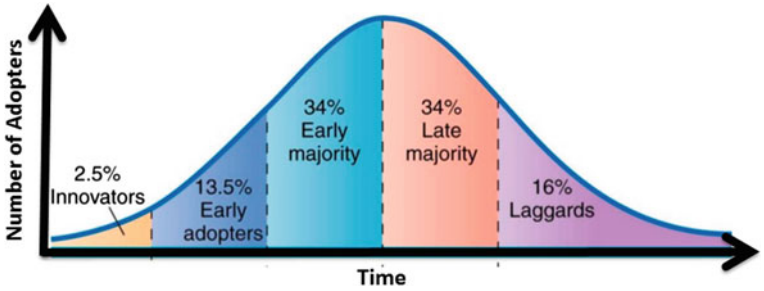

Fig. 1 Rogers' diffusion for the innovation adoption (Rogers Everett 1995)

are two common terms when it comes to the acceptance of technology; *adoption* and *diffusion*. Rogers et al. (2010) discussed thoroughly the adoption and diffusion of technological innovations and new products by a social system. Straub (2009) argued that the adoption is a micro-perspective on change to accept or reject an innovation, focusing on the smaller pieces that make up the whole. In contrast, the diffusion theory explains how an innovation spreads among larger population considering factors including time and social influence to describe how individuals adopt, reject or adapts to a technological product. Rogers (2010) visualized the process of adoption and diffusion over time as a normal distribution as shown in Fig. 3. The adoption model shows that the first group of individuals to adopt an innovation are called "*innovators*" who require a shorter adoption period. Followed by the "*early adopters*" who are described as opinion leaders and willing to try new ideas with caution. The next group is the "*early majority*" who are thoughtful and careful people to accepting change. The other group of people is called "*late majority*" being described as skeptic individuals who adopt a technology only when the majority of people use it. The last group to adopt innovation are called "*laggards*" who accept the technology only when it becomes mainstream or tradition. Rogers (2010) explained that the diffusion of innovation model implies that the patterns of technological adoption within a network of individuals, are determined and steered through a process of communication and social influence such that later adopters are informed and persuaded of the availability and usefulness of new products by the early adopters (Fig. 1).

The idea for 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 topic of adopting e-learning technology by the academic community, it has been a long source of academic research from multiple disciplines including education, psychology and computer science. This is motivated by the fact that the process for introducing e-learning systems and their adoption is bound to have a slow and complex trend (Persico et al. 2014). Numerous recent studies (McGill et al. 2014) have stressed that educational innovations can wither and be subverted if technological initiatives are not maintained and adopted

by the educational community. In fact, academics and teachers play a pivotal role for the successful adoption and diffusion of e-learning innovations. There is only a limited number of research studies on the acceptance and adoption of academics for the uptake of e-learning systems compared to the considerably body of research publications focusing on students (Hrtoňová et al. 2015; Šumak et al. 2011). Many theoretical models have been proposed to study and evaluate the adoption process whilst most of them explained that the adoption and acceptance process is driven by the following main constructs; ease of use, usefulness and social influence.

3.1 Ease of Use and Usability

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 the academic community (Persico et al. 2014; Phillips et al. 2012; Laurillard et al. 2009). Considerable criticism regarding the quality of existing e-learning systems are being cited by a number of studies (Chua and Dyson 2004) in addition to further issues including low performance and poor usability. The usability nature of educational software systems 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). The usability is a key characteristic to achieve the acceptance and adoption of technological product by academic staff 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. Meanwhile, other researchers have defined satisfaction as the gap between the expected gain and the actual gain when using the system (Tsai et al. 2007). Davis (1989) explained the ease of use as the perception of users that the system will be free from effort arguing that the ease of use has a direct impact for the intention to adopt the innovation.

There is an emerging body of literature on relating the usability aspect of information systems as important factor to influence the human behavior to accept new technological products. 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 and 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 et al. 2015). Software systems are valued on the basis of its graphical interface and the related power of communication and expression for the implemented functionalities. 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 et al. 2007; Ismailova 2017). Moreover, research focus has shifted recently

from the study of use to exploring ways of effective and ease of use for information systems to improve the adoption levels of technological products (Burton-Jones and Grange 2012).

3.2 Usefulness and Utility

e-Learning management systems are devised to supplement traditional teaching methods and improve the quality of knowledge and skill retentions. Academic institutions and corporations invested substantial amounts of funding to deploy learning management systems to assist their students and staff perform their desired tasks within an academic or training context. Davis (1989) defined the perceived usefulness as the extent to which an individual believes that using a particular technological product would improve their job performance. Usefulness is also defined by Phillips et al. (1994) as as "*the prospective adopter's subjective probability that applying the new technology from foreign sources will be beneficial to his personal and/or the adopting company's well being*". The authors explained that the usefulness or utility comprises of two dimensions including the perceived utility for the organization in addition to the perceived usefulness on the individual. For the academic community, the usefulness of educational systems is perceived from two perspectives including assisting academic staff and students to acquire more knowledge, decrease the time to perform a job and more efficiency. From another perspective, academic institutions and corporation perceive the utility of learning management systems as a way to improve its academic ranking, reputation as well as cut operational costs. Many studies have stressed that the perceived usefulness is a strong factor that shapes the user adoption to technological products (Davis et al. 1989; Phillips et al. 1994; Venkatesh and Morris 2000; Venkatesh and Davis 2000).

3.3 Social Influence

Consistently with the theory of diffusion for the innovation adoption (Rogers 2010), the social system has a strong influence to bring late adopters to accept an innovation. The social influence refers to the beliefs for an individual of whether other users want them to perform the desired task using the technological tool (McGillandKlobas 2009). Fishbein et al. (1975) explained the social norm as the degree to which a person believes that other important people to him/her would want him/her to perform this particular behavior i.e. make use of the technology to perform a particular task. The list of related people can include both peers and superiors whose influence is reported to be a strong factor for the social norm (Taylor and Todd 1995; Venkatesh and Morris 2000). Previous studies affirmed the existence of a direct influence of social factors on the successful uptake of technological systems (Hsu and Lin 2008). Within the academic context, the adoption of academics and students to use online

technology can be influenced by administrative staff (head of the department, dean of the faculty...), work colleagues and even students who prefer to access pedagogical materials from home.

4 Acceptance Evaluation Methods

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. Evaluation of e-learning applications in terms of user experience, satisfaction and acceptance has received recently considerable attention from the research community in order to assess and quantify the satisfaction and effectiveness level for academic users. This is due to the increasing concern that despite the wide use and deployment of e-learning technologies, the intended impact on education is not achieved (Phillips et al. 2012; Asarbakhsh and Sandars 2013). 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. In this section, two major categories are proposed to survey the different approaches for the adoption of e-learning systems based on the evaluation paradigms which are subjective and objective.

Garrison et al. (2011) listed four types of proactive evaluation starting with the determination of the strategic intent of the e-learning program. Being able to clearly determine the reasons why the particular pedagogical program has been devised for e-learning is important to assess its effectiveness. The second type of proactive evaluation is to look closely at the educational content of the courses and examine the cohesion and consistency facet 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.

4.1 Subjective Methods

Measurements obtained from subjective evaluation are derived from expressions, feedback and opinions of users about how they perceive the system or their interaction with the system. Subjective evaluation methods can be qualitative oriented where assessment is based on interviews, user comments or open-format questionnaire responses. Alternatively, measurements can be obtained quantitatively from users using mostly closed-format responses. In the arena of technology adoption, the majority of evaluation methods are based on creating an instrument to include questions set with responses on a Likert scale where respondents specify their answers as the level of agreement or disagreement in a symmetric fashion. Questionnaires are usually made to conform to a specific model composed of many inter-related constructs. There is a number of models 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 et al. (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 and Davis 2000). The model assess the acceptance of the system in terms of perceived usefulness and ease of use against actual usage behavior as shown in Fig. 2. For research studies related to assess the adoption aspect of the Moodle e-learning platform, 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 and 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.

Due to the limitation of the Technology Acceptance Model specifically for addressing the technology as a whole and its lack of task focus, Goodhue and Thompson (1995) introduced the Technology to Performance Chain (TPC) model to account for such drawback via combining both the utilization and Technology Task Fit (TTF). The TTF is defined by (Goodhue and Thompson 1995) as the degree to which a technology is utilized to assist a user to perform their tasks. For the Technology

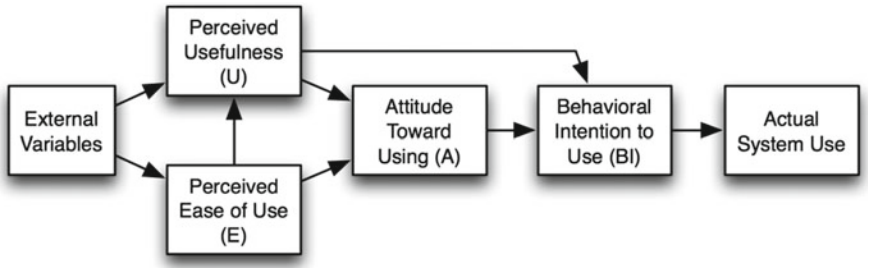

Fig. 2 Technology acceptance model (Davis et al. 1989)

Task Fit, the primary objective is the fitness between the task requirements and the characteristics of the technology which both have a direct impact on the TTF. The performance and utilization are in turn influenced by the TTF for performing a specific task using a particular technology. In spite of the fact that individuals perceive technology as an innovative advanced solution for their well-being, users will not uptake technological products if they think they are unsuitable to perform their tasks or unable to improve their work performance. In other words, the TTF argues that technological systems need to be willingly accepted by individuals as well as fit well with the tasks and users to prove its effectiveness and improved performance. Previous empirical studies have reported that combining the TTF and utilization models give better insight about the impact of technology on user performance better than the TAM alone (Dishaw and Strong 1999). There are other studies which proposed other variations via combining the TAM with the TTF including the work of Dishaw and Strong (1999). For the literature related to the use of TPC model in the academic arena, a few research studies have explored the interrelationship of technological products, academic needs, performance and TTF. McGill employed the TPC model for a number of educational case studies. In McGill and Hobbs (2008), the fit for using virtual learning environment is investigated for both teachers and students. Further, learning management systems are evaluated in terms of the *fit* degree for tasks performed by students (McGillandKlobas 2009) in addition to pedagogical tasks conducted by academic instructors (McGill et al. 2011). In a different study, Raven et al. (2010) used the TTF model to explore the fit for using digital video tools for giving presentation inside the classroom. The authors reported that significant fit between improving oral presentation skills and using video tools. Further, D'Ambra et al. (2013) applied the TTF model to assess the adoption of e-books by university students. Recently, Yi et al. (2016) considered a reduced model from the TPC to investigate the perceived performance for students to use their smart phones for accessing educational content within the academic context (Fig. 3).

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 *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

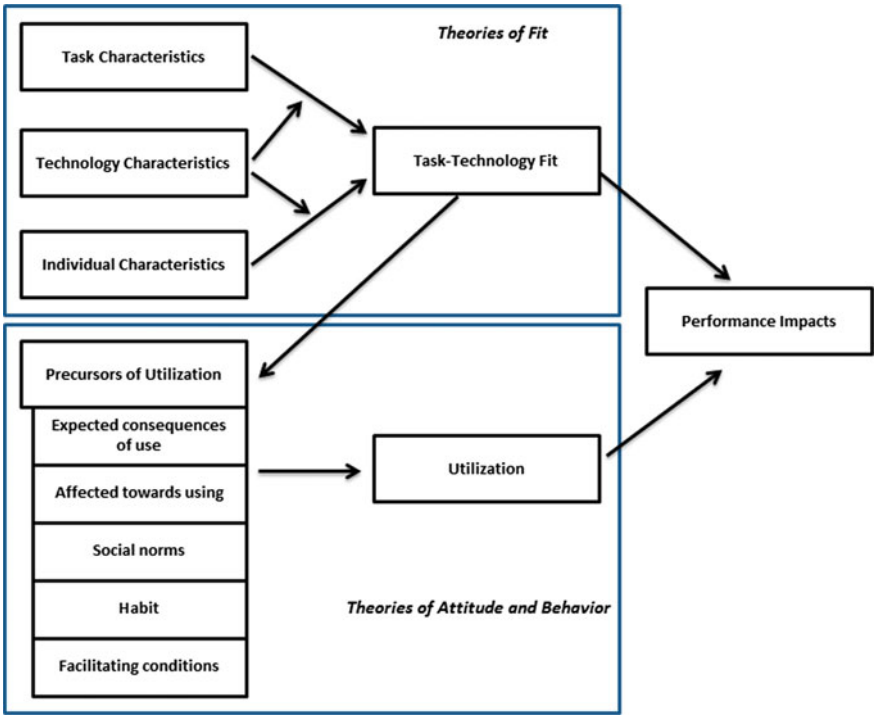

Fig. 3 The technology to performance chain (TPC) model (Goodhue and Thompson 1995)

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 (Sauro and Lewis 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 to strongly agree. The SUS scores ranges between 0 and 100 in 2.5-point increments where higher values reflect higher satisfaction from the user. Only a few studies in the literature have used SUS to evaluate the perceived usability of e-learning management systems (Orfanou et al. 2015). The first study of using the SUS for e-learning system was conducted by Renaut et al. (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 and de Moraes (2012), Simoes 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 and 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%.

4.2 Objective Methods

Although the majority of studies are purely based on subjective data analysis, Ivory et al. (2001) argued that automating the evaluation process for software systems in terms of acceptance and usability would help to increase the coverage of testing as well as reduce significantly the costs and time for the evaluation process. Objective methods are based on the quantification of variables by instrumentation as opposed to using by subjective human assessment. This is motivated by the fact that the process for introducing e-learning systems is bound to have a slow and complex trend (Persico et al. 2014) that needs to be understood and evaluated beyond the use of just summative and automated ways. Primarily, it is not surprising that a number of empirical studies have compared both self-reported subjective and objective measures for using an information system concluding that self-reported data are observed to be less accurate than objective measurements (Szajna 1996; Pentland 1989). Objective methods can range from analyzing completion tasks, interaction logs, usage frequency and even affective and medical data. Interestingly, there is a recent trend of using medical machines 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 et al. 2012). Liapis (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.

Several automated evaluation methods are conceived for auto discovery of usability faults at the same time alleviating the drawbacks in terms of reducing costs and time through liberating usability experts from conducting repetitive tasks manually. Further the coverage of tested features can be remarkably increased through the use of automated procedures (Quade et al. 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 (de Santana and Baranauskas 2015; Cassino et al. 2015). However, the majority of the surveyed research studies are purely based on manual or statistical analysis of recorded usage data for the participants. Methods for usability evaluation are conventionally grouped into two main categories; 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 and Tucci (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 and Baranauskas 2015).

Paganelli and Paternò (2002) developed 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 et al. 2012) which provides a graphical representation for the hierarchical logical structure of the task model. Tiedtke et al. (2002) described a framework implemented in Java and XML for automated usability evaluation of interactive websites combining different techniques for data-gathering and analysis. The system uses a task-based approach and incorporates usability issues. Atterer and Schmidt (2007) presented an implementation of a system called UsaProxy which is an application that provides usage tracking functionality using an HTTP proxy approach. Recently, de Vasconcelos and Baldochi (2012) implemented an automated system called USABILICS for remote evaluation. 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. Harrati et al. (2016, 2015) proposed an online automated system for formalizing user interactions with a given system guided through a set of rules describing certain goals is proposed. A task model is constructed 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 within the usability evaluation of the e-learning system in a non-intrusive fashion without the need to install additional tools. Empirical results performed to inspect the usability and utilization 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 software interface where the majority of lecturers failed to achieve satisfactory utilization.

5 Conclusions

The use of e-learning in academic and corporate institutions has gained popularity mainly due to the perceived advantages of flexibility around fitting the learner's time requirements and overcoming the issue around the geographical restrictions. Evaluation of e-learning applications in terms of user experience, satisfaction and acceptance has received recently considerable attention from the research community in order to assess and quantify the satisfaction and effectiveness level for academic users. This is due to the increasing concern that despite the wide use and deployment of e-learning technologies, the intended impact on education is not achieved. The dearth of conventional e-learning system quality models is in stark

contrast compared to the considerable body of work on software quality assurance. There is a number of models and theories in the literature for understanding, predicting, and assessing the interaction process with its involved parts including personal factors, behavior, and the environment. Two major categories are discussed to survey the different approaches for the adoption of e-learning systems based on the evaluation paradigms which are subjective and objective.

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